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ON SCHOOLS: WITH PARTICULAR REFERENCE TO TRADES SCHOOLS.

BY JOSEPH M. WILSON, A.M., C.E.
President of the FRANKLIN INSTITUTE.

[*Concluded from vol. cxxx, p. 220.*]

REGULATIONS SPECIAL TO ART.

Aid is given towards instruction in the branches of art named below, which for convenience of references are divided into stages, and there are three grades of examination, the first grade being for elementary schools only; the second grade, of a more advanced character, and the third grade of a still higher standard.

The different stages are as follows:

(1) Linear drawing by aid of instruments.

(2) Free-hand outline drawing of rigid forms from flat examples.

(3) Free-hand outline drawing from the "round."

(4) Shading from flat examples.

(5) Shading from the "round" or solid forms.

(6) Drawing the human figure and animal forms from flat examples.

(7) Drawing flowers, foliage and objects of natural history from flat examples.

(8) Drawing the human figure, or animal forms, from the "round" or nature.

(9) Anatomical studies.

(10) Drawing flowers, foliage, landscape details and objects of natural history from nature.

(11) Painting ornament from flat examples.

(12) Painting ornament from the cast, etc.

(13) Painting from flat examples, flowers, still-life, etc.

(14) Painting direct from nature.

(15) Painting (from nature) groups of still life, flowers, etc., as compositions of color.

(16) Painting the human figure or animals in monochrome from casts.

(17) Painting the human figure or animals in color.

(18) Modelling ornament.

(19) Modelling the human figure or animals.

(20) Modelling fruits, flowers, foliage and objects of natural history from nature.

(21) Time sketches in clay of the human figure, or animals, from nature.

(22) Elementary design.

(23) Applied designs technical or miscellaneous studies.

Grants are made towards the cost of fittings, the purchase of apparatus, examples and works of reference, in accordance with certain conditions.

In schools of art, both day and night classes must be held, and there must be a night class for artisans, meeting under the instruction of the master for two hours, at least three times a week, during forty weeks in the year.

There are rules governing the formation of branch classes; qualifications of teachers; granting of certificates, and regulations as to students, which need not be considered here. There are also special rules as to examinations, regulations as to works sent to South Kensington for examination, etc.

Grants are made for travelling, to masters and students, to enable a limited number of those connected with schools of art to see the works not only at home but also in special cases in foreign towns, schools and galleries, to make sketches, to study, or to do special work for the Department.

A national training-school is established in London, for the purpose of training art masters and mistresses for the United Kingdom, and for the instruction of students in drawing, designing, and modelling, to be applied to architecture and manufactures. Free admission to the courses of instruction is granted to students in training, national scholars and free students. Admission is also granted to the general public on payment of fees. The school is open for study every week-day, excepting Saturday, from 9 A.M. to 4 P.M. with an interval of half an hour for lunch, and from 7 P.M. to 9 P.M. and all life classes and class lectures commence at 10 and close at 3.30. The annual session consists of two terms, each lasting five months.

Aid is extended by the department of science and art, to the advancement of drawing in the elementary schools, and to training-colleges for teachers, but the details are not pertinent to the present inquiry.

It is believed that the extracts which have been given from the directory of the Department, which have been mostly verbatim, are sufficient to enable those interested in the subject to obtain a fair idea of the work embraced by this Board of the Council on Education. Still further information can be obtained, however, from the directory itself, if desired.

THE CITY AND GUILDS OF LONDON INSTITUTE FOR THE ADVANCEMENT OF TECHNICAL EDUCATION.

This Institute owes its origin to the city livery companies of London, and it was established for the purpose of providing and encouraging education, such as will be adapted to the requirements of all classes of persons engaged, or preparing to engage, in manufacturing and other industries.

In carrying out its object, it arranges to subsidize existing educational establishments which, in the opinion of the Council of the Institute, are already providing sound technical instruction, and which, if not supplied with external aid, would possibly languish or fail in their purpose.

This Institute also encourages, in the principal industrial centres of Great Britain, the formation of evening classes, in which workmen and foremen, engaged in their business during the day, can receive special instruction in the principles of science, in their application to the processes with the practical details of which they are already familiar.

It aims at establishing and maintaining in London model technical schools, to serve as examples for other schools that may be founded and supported by local efforts in provincial towns; and it has erected and supports a central institution to serve as a great polytechnic school corresponding in its purpose to those of Germany, Switzerland and Italy, and to the École Centrale of Paris, obviating the necessity of students going abroad for technical education. The City and Guilds of London Institute fills up the interval between the school and the workshop, and assists in the professional instruction of all classes of persons engaged in industrial pursuits—of artisans, apprentices, foremen, managers of works, manufacturers and technical teachers; not in any way proposing to interfere with existing social institutions, such as apprenticeship, or other relations between the master and workman, but only to provide for a long-felt and pressing want, in supplementing the training of the workshop by instruction in the general principles underlying the profession of the student, giving him what it is impossible for him to obtain in the best organized shop, and enabling him the better to profit by the training he does get, when he enters the shop.

In order to establish technical classes in London and in provincial manufacturing towns, the Institute granted, for a period of years, certain annual sums, ranging from £400 to 200, to University College, London; Kings College, London; Horological Institute; School of Art Wood-Carving; Firth College, Sheffield; University College, Sheffield; and Technical School, Manchester.

It has also given considerable sums to other Institutions, and in nearly all the large manufacturing towns it is assisting evening classes in technology, as distinguished from the government classes in science and art. The Institute attends to the inspection and examination of the work done by the students of these classes and grants certificates and prizes to those deserving them, these, as diplomas of proficiency, being of great value in enabling operatives to obtain better employment and higher remuneration. These evening classes, are the nuclei of technical colleges, principally supported by the towns in which they originate, but connected with, and affiliated to the parent Institute by means of the examinations and supervising influence which it has over them.

Studies are prosecuted and examinations held in such subjects as the following: (Programme of 1883–4.) Salt and alkali manufacture; soap manufacture; bread-making; brewing; distilling of coal tar and manufacture of spirits; sugar manufacture; fuel; manufacture of oils; colors and varnishes; oils and fats, including candle manufacture; gas manufacture; manufacture of iron and steel; of paper and porcelain, of glass; dyeing in silk and wool; bleaching, dyeing and printing of calico or linen; tanning of leather; photography; electro-metallurgy; manufacture of textile fabrics; lace manufacture; weaving and pattern designing; electrical engineering; metal plate work; plumber's work; silversmith's work; watch and clock-making; tools, wood-working and metal-working; mechanical engineering; carriage building; printing; mechanical preparation of ores; mine surveying; milling; carpentry and joinery.

The Finsbury Technical College, which was opened in 1883, was erected at a cost of £36,000 by the City and Guilds of London Institute, as a model trade-school, where artisans and others preparing for intermediate posts in industrial works could be instructed. It is a school of applied science and art, with day and evening classes, the latter providing systematic instruction for those who are engaged in the staple industries of the district, including cabinet-making; and in the applications of chemistry, mechanics and physics to special trades.

This college has made an approach to the establishment of a relationship with the principal middle-class schools of the metropolis, by the award, to selected pupils from these schools, of exhibitions, enabling them, without payment or fees, to receive in the college, scientific and technical training, fitting them for various occupations and industries, as well as for higher technical instruction.

The subjects taught comprise mathematics, pure and applied; practical mechanics, chemistry and physics; electrical technology; free-hand, model and machine drawing; workshop practice; French and German; and in the evening, additional classes are held in carpentry and joinery; metal plate work; bricklaying; drawing; painting; modelling, and design.

The South London Technical Art School, which is also under the auspices of the City and Guilds of London Institute, provides instruction for artisans engaged in various industries where aptitude in arts is essential to success. The courses provide for evening and day students, men and women, and the subjects of instruction include drawing, modelling and painting from life; wood-engraving; china-painting; enamelling and design.

The Central Institution of the City and Guilds of London Technical Institute, is located on the Exhibition Road, opposite to the South Kensington Museum and close to the Natural History Museum. It provides a high-class technical college where teachers for the provincial schools may be educated, and where students may be trained to take positions of trust in charge of great industrial works and manufactories.

The building has a frontage of about 300 feet, and is for the most part five stories in height. In the basement are the engineering work-shops and laboratory, the forge-room, dynamo-rooms, dynamo and motor-testing room, physical laboratories, the laboratory of mechanics, and the joiners' shop. The ground floor is mainly occupied by class-rooms, the entrance hall being in the centre of the building, and the great corridor extending from one end to the other. The optical laboratory and private rooms for three of the professors are also on this floor.

Over the entrance, on the first floor, is a large reading-room and library, the balance of this floor being used for physical laboratories and the offices of administration. The second floor has a large room in the centre, used as a museum for engineering, mathematical and physical models, and in the other portions are chemical laboratories, lecture-rooms, applied art studios, and a school of wood-carving, the latter not properly belonging to the school and only allowed temporary room. A large room on the third floor is used as an engineering drawing office, and other rooms for chemical laboratories, also a students' refreshment-room. At the back of the building are two large lecture-rooms, one for chemistry, and the other for physics and mechanics.

This technical Institute was opened in June, 1884, with such men at its head as Profs. Henrici, Unwin, Ayrton and Armstrong, each aided by a staff of assistants. The subjects of instruction were indicated to be chemistry, engineering, mechanics, mathematics, physics, drawing, manufacturing technology, workshop practice, modern languages and applied art, and in addition to the three complete courses specially arranged for students to enter engineering, electrical or chemical industries; those who are sufficiently advanced are admitted to any course they may select, or to do special work in the laboratories, working as many hours a week as they desire.

Short courses of lectures and laboratory demonstrations on various branches of applied science and the technology of particular industries are given during the summer by the professors and outside lecturers, especially adapted to the requirements of the technological teachers of the Institute, who have free admission to them, and also open to other persons on the payment of small fees.

Students entering the Institute for the complete course must pass an entrance or matriculation examination in elementary mathematics and mechanics, mechanical drawing, physics, chemistry and either French or German. This examination takes place at the end of September, and is open to all persons of not less than sixteen years of age. There

are several scholarships of a value running from £60 a year, together with free education, down to £30 a year, which are awarded at this time on the results of the examination, making the contest very interesting. The regular courses begin in October and continue until the end of June, with the usual Christmas and Easter vacations. The complete course is three years, the first year being the same for all students.

It seems hardly necessary to give details of the various studies and the methods of teaching, etc., as it is very similar to what is adopted in the best technical schools of the United States, and the subject is a little beyond the special object of this paper; but it may be stated that every effort is made to combine practical work with high theoretical teaching; the workshops and laboratories are well equipped, and students are taught at each step to apply their theoretical knowledge to practical problems, the result being that they are prepared for grappling successfully with the great questions which will come to them in their future career; their interest is awakened, even with dull students, to the practical value of what they learn, and at the same time, the professors have the best possible test of the reality and thoroughness of the knowledge they gain. A series of very interesting papers on this Institute will be found in *London Engineering*, vol. xlvi, 1888.

THE POLYTECHNIC YOUNG MEN'S CHRISTIAN INSTITUTE, REGENT STREET, LONDON.

This Institute originated many years ago as a philanthropic effort, and in its first form took the shape of a ragged school. After that it developed into a semi-scientific exhibition, where such things as "Pepper's Ghost," the "Automaton Chess Player," etc., were the principal attractions. Then it was purchased by Mr. Quintin Hogg, and transformed by him into a Young Men's Christian Institute, a polytechnic not only in name but in fact, with its educational and technical classes, athletic and gymnastic clubs, recreation societies, etc. It is in a very flourishing condition, thousands of young men annually pass through its various

classes, and the number of its members has increased until the capacity of the immense building is severely taxed. What Mr. Hogg has done for the young men, Mrs. Hogg has accomplished for the young women, and it is an institute for both sexes, the department for the former being at 309 Regent Street, and for the latter at 15 Langham Place. Mr. Quintin Hogg is President of both departments.

That for young men is intended for artisans, apprentices and others; the building is open every evening, Sundays and bank holidays excepted, from 5.30 until 10.30, and all between the ages of sixteen and twenty-five are eligible for membership. A subscription of three shillings per quarter, payable in advance, entitles members to the free use of the library, reading, social, chess and draughts rooms, also to the use of the splendid gymnasium, admission to the swimming-bath, concerts, entertainments, lectures, etc., and the privilege of joining any of the classes, at greatly reduced rates.

A recreation ground of twenty-seven acres, at Merton Hall, Wimbledon, is reserved for the use of members. Many societies and clubs are formed from among the members, and are managed by their own committees.

Young men of eligible age wishing to join the Institute, enter their names in the candidates' register, at the office, at the same time paying a registration fee of one shilling, which will constitute their entrance fee when they become members. As vacancies occur, candidates are communicated with by the Secretary in the order of their registration.

The swimming-bath, said to be one of the handsomest in the kingdom, adjoins the gymnasium, and is open for members from May until October. There are swimming races held weekly, and the Institute challenge cup is swum for, monthly, during the season. A fee of three pence is charged for admission to the swimming-bath, and instruction is given every evening free.

The gymnasium is under the charge of a first-class certificated instructor, with qualified assistants, and members of the Institute have the use of the gymnasium, with

private locker, for three shillings per annum. Squad and mass exercise take place every evening, and instruction is given in single stick, fencing, dumb-bell, indian club, bar bell, horizontal bar, parallel bars, rings, trapeze, etc. Displays are frequently given by members in different parts of London.

The following societies and clubs are held in connection with the Institute: Polytechnic Sick Fund; Christian Workers' Union; Total Abstinence Society; Athletic Club, with ground at Merton Hall; Cycling Club; Polytechnic Rambles, with walking excursions into the country every Saturday afternoon; Polytechnic Harriers, one of the Premier Clubs of London; Boxing Club; Mutual Improvement Society; Polytechnic "E" Company (West London Rifles), fourth Middlesex; Volunteer Medical Staff Corps; Polytechnic Battery, No. 7, First City of London Artillery Volunteers; Polytechnic Company, First Middlesex Engineers; Polytechnic Military Band; Orchestral Society; Male Choir; Choral Society; Chess and Draughts Club; Short-hand Society; Literary Society; Polytechnic Parliament; Polytechnic German Society; French Society; Electrical Engineering Society; Engineering Society; Savings Bank; Insurance against Accidents; Polytechnic Physical Development Society.

The Institute is intended principally for apprentices and young artisans, and these constitute the mass of the members, although others are admitted. Special efforts are made in the educational department to provide the members with the opportunity of acquiring a sound theoretical and practical knowledge of their various trades, and care has been taken that the instruction should not be too difficult to be understood by the average mechanic. The classes of the educational department are open to both sexes of all ages, members and non-members, the fees being higher for the latter. During the session of 1888–1889, the number of individual students enrolled exceeded 8,846. The workshops are replete with requirements, and the photographic studio is one of the best in London. Lavatories, refreshment bar, etc., are also provided for the convenience of

students. The practical and technical classes are limited to members of the trade in question.

The classes in this department are divided under the following heads: Technical; practical trade; commercial and general; special examination preparatory; science; musical; elocution, and Saturday classes.

The technical class subjects are bread-making; brickwork and masonry; carpentry and joinery; cabinet-making; carriage building; electrical engineering; mechanical engineering; metal-plate working; typography; lithography; photography; plumbing; boot and shoemaking; watch-making; quantities and estimating; oils and fats; tools.

The practical trade classes comprise: Brass finishing; brick-cutting: cabinet-making; chasing and repoussé; carpentry and joinery; stair-case and hand-railing; electrical work; metal-turning and finishing; upholstery; tailor's cutting; plumbing; wood-carving; watch-making; etching.

The commercial and general classes include: Arithmetic; book-keeping; composition; writing; grammar; reading and spelling; French; German; short-hand; typewriting.

The special examination preparatory classes are intended for preparation for the different civil-service examinations and for medical and pharmaceutical preliminary and Latin elementary examinations.

The science classes are for: Agriculture; geology; geometry; machine construction; magnetism and electricity; mechanics, theoretical and applied; mathematics; mineralogy; physiography; botany; sound, light, heat; steam and steam engineering; animal physiology; hygiene; chemistry, inorganic and organic; building construction.

The musical and elocution classes teach the specialties in those departments, and the Saturday classes are arranged for chemistry; geometry; machine construction; French; art modelling, etc., and short-hand.

The Polytechnic School of Art Department of this Institute is at 155 Great Fitchfield Street, in connection with South Kensington, and is open for students of both sexes.

It is considered one of the largest Metropolitan schools of art and possesses a very large collection of statuary and casts, together with a fine antique gallery. It is stated that the number of successes in the examinations and of prizes obtained by students in this school places it in the front rank of Government schools of art. There is a day department, and also an evening department for artisans and others obtaining their own livelihood, and who undertake to attend the Government examinations in May. Members of the Institute obtain a reduction in fees, as also apprentices and pupil-teachers.

The school teaches free-hand and model drawing; geometry and perspective; drawing from the cast and antique; painting in monochrome, oil and water colors, designing, etc.; drawing, painting and modelling from life; drawing and painting from still life; modelling in clay and wax; wood-carving; etching on copper; ornamental design; chasing and repoussé work.

Prizes, in value from about $5 to $25 each, are offered to competitors in the school of art for best designs, drawings, modellings, etc., by such men as the Duke of Westminster, Earl of Aberdeen, Lord Kinnard and firms, such as Winsor & Newton, etc.

At the Young Women's Department of the Institute in Langham Place, those between the ages of sixteen and twenty-five are eligible for membership, and the building is open from 6.30 until 10 P.M., Sundays and bank holidays excepted, the gymnasium being open only on Tuesday and Thursday evenings. A subscription of 1*s.* 6*d.* per quarter, or five shillings per annum, payable in advance, entitles members, amongst other privileges, to the use of the reading-room and social-rooms; admission to concerts, lectures, entertainments, etc., at member's rates, and the privilege of joining any of the classes at greatly reduced fees.

The swimming-bath is reserved on Friday nights for members and their friends; admission, three pence for members and four pence for friends.

Bible classes are conducted on Monday evenings and on Sunday afternoons. In this connection we may mention

that in the Young Men's Department there is held on Sunday what is stated to be one of the largest Bible classes in the world.

The table of special classes for young women only, comprises: Ambulance, book-keeping, arithmetic, French, elocution, civil service, telegraphing, writing, violin, piano, harmonium, dress cutting and making, millinery, cookery, typewriting, etc.

The courses of instruction in plain and high-class cookery are very complete; special attention is paid to individual requirements and to giving good practical instruction in household cookery. The number of students in the practical classes is limited to twenty.

The fees in the high-class cookery, practical department, are, for non-members, five shillings, and for members, 3*s.* 6*d.*, while for the demonstration they are, non-members, two shillings; members, one shilling, and single lessons, three pence. In household cookery, the fees for the practical course are, non-members, 3*s.* 6*d.*; members, 2*s.* 6*d.*, and for the demonstration, non-members, one shilling; members, sixpence; single lectures, twopence.

The St. John ambulance, for rendering first aid to the injured and home nursing, is connected with this Institution, and a special course of lectures and demonstrations is given for ladies only, each lecture lasting one hour, a second hour being devoted to practical instruction in bandaging.

After the course is over an examination is held for those desirous of obtaining the St. John Ambulance Society's Certificate. The tickets for the course are 10*s.* 6*d.* each.

THE PEOPLE'S PALACE TECHNICAL SCHOOLS.

What the Polytechnic is doing for the neighborhood of Regent Street, the People's Palace is doing for East London. This is a large institution for the "recreation and amusement, the intellectual and material advancement, of the vast artisan population of the East End." Its form was suggested by the Palace of Delight" described in Mr. Walter Besant's novel, "All Sorts of Conditions of Men," and the nucleus of the £100,000 required for its erection, was fur-

nished by an endownment of Mr. J. F. Barber Beaumont, who died in 1841, which was largely increased by voluntary public subscriptions, including £60,000 from the Drapers Company of London.

The great central building, the "Queen's Hall," was opened by Queen Victoria in May, 1887, and active work was begun in the palace in October of that year.

The buildings are not yet entirely completed, and some of those that are in use are only temporary, but good service is made of the facilities already provided and a great work is being done.

The present permanent buildings consist of the Queen's Hall, a beautiful audience-room, capable of seating 3,500 people, and nearly 6,000 have been in it at one time; a library, now containing over 12,000 volumes, absolutely free to the public, although books cannot be taken out of it; and a four-story structure on the east of the hall, devoted to the educational department and appropriated as follows: The basement contains men's and women's cloak-rooms and lavatories, the engine-room, engineer's-room, pattern-making and moulding-room, brick-work and masonry-room and electric laboratory; on the ground floor are the administrative offices, the lecture-room, with gallery over, the mechanical drawing-room, and a class-room; the first floor comprises a building construction drawing-room, the head master's room, men teacher's room, and class-rooms; the third floor accommodates the chemical laboratories, class-rooms and a lecture-room; and in the roof is the photographic studio. In addition to these buildings, there is a swimming-bath, containing a pool 90 feet long by 60 feet wide, 6 feet deep at one end and 4 feet at the other, the water in it being entirely changed every day; and also the refreshment building and gymnasium, which are temporary for the present, until arrangements can be made for permanent structures.

The work of the Institution may be considered under three general heads: The recreative section, the educational section, and the social or institute section. The report of the Chairman of Trustees, Sir Edmund Hay Currie,

for October 1, 1888, the latest annual report at my disposal, gives some idea of the work carried on.

In the recreative section, exhibitions and shows are held. Thus there was from October 26 to 30, 1887, a poultry and pigeon show, the charge for admission being fixed at twopence. Over 36,500 persons attended; many valuable money and other prizes were given, and great interest was shown in the exhibits by the inhabitants of many quarters of the East End. Then, on November 16th of the same year, the Princess Christian visited the palace and opened a show of chrysanthemums, nearly 20,000 people attending, at the low rate of admission of twopence for adults and one penny for children.

On December 10th, the Prince of Wales opened an exhibition of the work of London apprentices, and announced the granting of an endowment by the Charity Commissioners of £2,500 a year and the gift by the Drapers Company of £40,000 for the same purpose. This exhibition remained opened until January 7, 1888, and was visited by 86,000 persons, there being nearly 30,000 present on boxing day and the day following. Prizes and souvenirs were given as awards for creditable work exhibited, and the undertaking was a great success.

Other shows and exhibitions were given from time to time with like results. On Good Friday there was a special free organ recital, attracting nearly 800 persons, and in the evening a fine rendition of the "Messiah," admission threepence, which was attended by 3,363. During Easter week, a concert was given every night, with a total attendance of 35,861. In April, a series of afternoon entertainments were given to children, for three days, with an attendance of 7,771, and afterwards, on four Saturdays, with an average attendance each day of 1,500.

In May, there was a workman's exhibition, open for six weeks, perhaps the most important exhibition of the year, over 96,000 persons visiting it.

In July, a donkey and pony show was held, for two days, attracting nearly 7,000 persons to it. Each man exhibiting for both days, received 7*s.* 6*d.* for his time, and those

exhibiting only one day, 2*s.* 6*d.* each. The Royal Society for the Prevention of Cruelty to Animals and the Coster's Society, each contributed toward the expenses of this show.

In August and September, there was an exhibition of modern pictures, and a six weeks' autumn *fête*, which was one of the most successful undertakings made in the People's Palace. There were some 150 pictures exhibited, including many specimens of the works of Watts, Richmond, Millais, Hook, Landseer, Alma Tadema, Hallé, Faed, and many other well-known artists. During the first few days of the *fête*, a flower show was held in the centre of the Queen's Hall, and during the whole period, the exhibition buildings were partly laid out as a garden and palm-house; a platform was provided for music, and numerous side-shows and other attractions were given, everything possible being done to make the place bright and attractive for the people. The charge for admission was fixed at a penny, and 310,207 persons came during the six weeks, 27,055 attending on bank holiday alone, and nearly 70,000 during the first week. The utmost comfort and good humor prevailed among these large masses of people, and even the very poor, to whom even the charge of twopence or threepence is at times almost prohibitive, flocked in very large numbers through the turnstiles, at the low price—very poorly-dressed men, women and children, indeed, forming the bulk of the visitors.

During the whole of the year, except during the autumn *fête*, concerts were held twice a week in the Queen's Hall, and on special occasions more frequently, the average attendance at these concerts being about 2,500. Arrangements are now made to set apart Wednesday evenings during the whole session, entirely for concerts and entertainments of various kinds, students being admitted to these by payment of sixpence per quarter, in addition to the class fees. These entertainments are of high class, and are arranged especially to interest and give wholesome pleasure to the people. Concerts are also arranged for on Saturday evenings. These entertainments are open to the public, the charges for Wednesday evenings being threepence, and

for Saturdays twopence. Sometimes a profit is made, and at other times there is a deficiency which must be made up.

Sacred musical recitals are given every Sunday, at 12 noon, 4 P.M., and 8 P.M., upon the very fine organ which has been presented to the Palace, and the average attendance has been almost 1,000, nearly all men. It is believed that much good results from these concerts.

The free library and reading-room are well patronized, the report for 1888 giving an average of from 900 to 1,000 readers on week-days and 1,750 on Sundays. The rooms are open on Saturdays until 10 P. M. Numbers of ladies and gentlemen give their assistance in the library on Sunday, without which it would be impossible to carry out the work, as no paid services are employed on that day. The reading-room is opened at 7.30 each morning, for the convenience of men out of work, who desire to consult advertisement columns, etc.

The swimming-bath proved to be a success at once, as many as 1,292 being admitted in one day during its first summer, and nearly 70,000 having availed themselves of its privileges in four and a half months. On Tuesdays it is reserved for women only. Boys from the public elementary schools in the district are admitted every morning except on Saturday, from six to eight, at a charge of one penny.

A large refreshment and drill-room provides good, wholesome, cheap dinners or lunches, for the pupils and others, the public being also admitted, and great care is exercised to furnish food of good quality and well cooked, at reasonable prices.

The educational section is doing good work. The technical school is operated in connection with the science and art department, South Kensington, the City and Guilds of London Institute, and the Society of Arts.

Boys to be eligible for the technical day-school, must be over twelve years of age: must have passed at least the fifth Standard, or an equivalent examination; and must be the sons of parents whose income is under £200 per annum. The courses of study are arranged to meet the require-

ments of those who intend to follow either of the following trades or professions:

Carpenters and joiners,
Cabinet-makers,
Engineers, electrical engineers,
Smiths and metal workers,
Designers,

and any of the chemical industries.

The fees are one shilling per week, or ten shillings per school-term, the school-terms averaging a little over two and a half months each.

A limited number of boys are admitted whose parents' income exceeds £200 per annum; the fees being £8 8*s.* per annum.

A large number of boys are admitted on free scholarships, subscribed by friends and others, after a competitive examination, open to boys attending public elementary schools in certain districts.

There were last October about 400 boys attending the classes, of which 300 were in the junior section. The hours are from 9 A. M. to 4.15 P. M., with one hour intermission at dinner-time, and one-fourth hour recess in the morning. The boys are divided into four sections, and each boy receives thirty and one-fourth hours' instruction in the week, the subjects taught being mathematics, mechanics, practical plane and solid geometry, machine or building construction and drawing, experimental physics, free-hand drawing and designing, model drawing, special handicraft work, drill and swimming, the latter, however, being in addition to the thirty and one-fourth hours' weekly work.

After the course for the first year, the studies tend to become specialized. Thus, those inclining to chemistry give more attention to that subject, electrical engineers study magnetism and electricity, mechanical engineers apply themselves to mechanics, etc. In the third year, the students are still more particularly kept at special studies, perhaps only chemistry, or only metallurgy, or physics, etc., depending upon the subject selected.

The chief difficulty to be contended with in the day-

school, is that of inducing the parents to allow their boys to remain for a longer time than the first year. Too much cannot be said regarding the importance of the pupil receiving at least two, and, if possible, three years' technical school instruction, and it is readily seen that more than one year's study is necessary for them to become acquainted with even the elementary principles of the subjects taught.

At the time of my visit nothing had yet been actually done for girls in the day-schools, as there had not been sufficient accommodation for them in the buildings; but last October a junior section was just about being started for girls of from thirteen to sixteen years of age, who had already passed through the elementary schools.

It is at the evening classes that the greatest attendance is observed, and the most encouraging success. There are on the rolls about 5,000 students, but only about 2,500 are present at one time, as many come for only one or two hours in the week, say to one or two classes. The evening classes are open to both sexes of all ages.

Only those are eligible to the practical trade or technical classes who are actually engaged in the trades to which these subjects refer, unless an extra fee is paid. The practical trade classes are:

Tailors' cutting,
Upholstery,
Photography,
Plumbing,
Cabinet-making,
Engineering,
Carpentry and joinery,
Wood-carving.

The technical classes are:

Boot and shoemaking,
Mechanical engineering,
Photography,
Carpentry and joinery,
Printing (letter-press),
Electrical engineering,
Electric lighting,
Instrument making and telegraphy,
Laboratory and workshop practice,
Plumbing,
Brickwork and masonry,
Cabinet designing.

The science classes comprise:

Practical, plane and solid geometry,
Machine construction and drawing,

Building construction and drawing,
Mathematics,
Theoretical mechanics,
Sound, light and heat,
Magnetism and electricity,
Steam and the steam-engine,
Applied mechanics,
Chemistry, inorganic and organic.

The fees vary more or less for the different subjects in all three classes, and members of some classes have special privileges for other classes. In the practical trade classes the fees run from 5*s.* to 8*s.* 6*d.* per quarter; in the technical classes from 4*s.* to 7*s.* 6*d.* per session, and in the science classes they are generally four shillings per session, although in special cases they are higher, even up to fifteen shillings.

The art classes, which are held at Essex House, Mile End Road, teach free-hand and model drawing, perspective, drawing from the antique, decorative designing, modelling in clay, etc., drawing from life, etching, wood carving, repoussé work and engraving.

The musical classes teach singing, piano-forte and violin, and there are choral and orchestral societies and a military band. Fees from two shillings to nine shillings per quarter.

The general classes comprise:

Arithmetic, book-keeping, civil-service work in all its different departments, including excise, customs and telegraphy, short-hand, French, German, elocution, writing, Shakespeare class, London University examinations, land surveying and levelling, ambulance, nursing and chess. The fees are very variable, running from one shilling per quarter for chess, to twenty-one shillings for university examinations, but the ordinary subjects are from 2*s.* 6*d.* to four shillings.

There are special classes for females only in dressmaking, millinery and cookery, also in elementary studies, including reading, writing, arithmetic, etc., and in elocution. The fees run from 2*s.* 6*d.* to 7*s.* 6*d.* per quarter.

The gymnasium is very complete, a regular series of classes being organized under a chief instructor with assist-

ants, and certain evenings and hours are assigned to certain subjects. The fees are only *1s. 6d.* per quarter, entitling the member to join any or all of the classes except boxing, for which an extra fee of sixpence is charged.

A junior section is provided for pupils from thirteen to sixteen years of age, and a ladies' gymnasium is held in Queen's Hall, for which the fees are one shilling per quarter. Each member of the gymnasium classes is provided with a locker in which to keep gymnastic attire, free of cost.

The staff of teachers in the education section is quite large, and very many are only specialists in certain subjects, coming just at the hours for those classes.

The social section of the People's Palace shows equal success with the other sections. During the year ending October, 1888, some 4,200 young men and women, between the ages of fifteen and twenty-five, joined the Institute, paying a subscription of *2s. 6d.* per quarter, or *7s. 6d.* for the year, for the young men; *1s. 6d.* per quarter, or five shillings for the year, for the young women. The number for 1888–89 was undoubtedly still larger. These members have free admission to all concerts, exhibitions, shows, etc.; the use of the gymnasium, the billiard and game-rooms, and admission to the swimming-bath at the reduced charge of twopence and eligibility for election to membership in any of the various clubs and societies connected with the Institute. There are some twenty-one clubs, comprising a chess and draughts club, a debating society, a choral society, a military band, an orchestral band, a sketching club, an art society, a photographic society, a girls' social club; swimming, foot-ball, harriers, cricket, cycling and billiard clubs, etc. The funds of these clubs are deposited at the Institute office, and remain in charge of the trustees.

Teas, conversaziones with dancing, evening dances, etc., are given, mention being made, in the annual report, of two evening dances, the attendance, which is restricted to members and their friends, being 1,100 at one time and 1,400 at the other. The general quiet and good behavior at these festivities were the subject of very favorable comment.

The number of members belonging to the gymnasium is very large, and the attendance varies from about 300 per night up, occasionally, to as many as 800. Gymnastic displays are given and competitions with prizes. That special part of the social department relating to young women has, also, been very successful.

Excellent accommodation for the cricket and foot-ball clubs is provided by the corporation of the city of London, in the use of about ten acres of ground at a convenient site, within easy reach of the Palace by the Great Eastern Railway, on which tickets are issued to members of the clubs at reduced rates.

The annual report, previously quoted, states that over 1,500,000 persons had visited the palace during that year, 1887–88, and not the slightest mischief or ill-behavior had resulted upon the gathering together of these large numbers of poor people. The most serious difficulties have been in obtaining sufficient funds to carry out all the work that presents itself, and the want of full accommodation. Much as the People's Palace is doing, there is still a great future before it.

Among other English institutions, might be mentioned the Home Arts and Industries Association, formerly Cottage Arts Association, which was started some years ago by a few amateurs, opening Saturday classes for teaching artistic handicrafts to the working boys and men of their own neighborhood, and, as the success of the experiment became assured, the project was extended and enlarged, until it became necessary in some cases to employ professional aid, and finally to perfect and adopt the present organization.

Through the agency of this association, the number of classes has been greatly increased, and the philanthropic interest in the claims of handwork as a part of education has been widely developed. The object of the association is to spread a knowledge of artistic handwork among the people, and to develop by instruction the perceptive faculties and manual skill of the pupils and prepare them for entrance into trades, at the same time increasing their

resources and enjoyments. Its work is accomplished by the following methods:

(1) The organization of classes in which attendance is voluntary and teaching almost entirely so.

(2) The lending to these classes of good designs and plaster models, and the circulation of manuals and pamphlets on industrial and artistic education.

(3) The employment of honorary local secretaries to carry out the work in country districts.

(4) The maintenance of a central office and studios in London, where both voluntary and paid teachers can be trained.

(5) The publication of a yearly report recording the progress of the work and such successful experiments in teaching as may prove useful to class-holders.

(6) The holding of a yearly exhibition and sale in London, where the work done in the various classes may be compared and criticised, and certificates of merit, medals, etc., be awarded for progressive attainment.

The minor arts at present being taught in the local classes are: Drawing and design, modelling, casting, joinery, carving in wood and chalk, repoussé work in brass and copper, hand-spinning and weaving, embroidery, pottery and tile-painting, embossed leather work, mosaic setting and basket-making, bent iron and rug-making.

The association is sustained by contributions of members, working members' fees, donations, subscriptions, etc.

Classes are of two kinds—training classes and ordinary classes. The question whether pupils in ordinary classes are required to pay for their lessons or not, is decided by local considerations, but the classes are eventually rendered self-supporting by means of a percentage charged on the work sold. The first outlay is met by local subscriptions. The central classes require a fee of 2*s.* 6*d.* per lesson, preference being always given to members of the association and to students who intend to assist in teaching.

The Guild and School of Handicraft is an organization which has for its object the application of art to industry, being a co-operative society of workmen, working out origi-

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nal designs for sale. The effort is made to apply the Guild system of mediæval Italy to modern industrial needs and to the movement for technical education. In connection with this Guild, and dependent upon it, is a school of about 100 workingmen and boys. The lines of work at present undertaken by this Guild are working in wood and metal, decorative painting, and the complete furnishing, fitting and decorating of houses.

The Society of Arts, London, takes great interest in questions of elementary and technical education, and important papers appear from time to time in the pages of its journal. Among others I would refer to one by Mr. William Lant Carpenter, February 10, 1888; one by Mr. Swire Smith, on "The Technical Education Bill," February 24, 1888; and one on "Scientific and Technical Instruction in Elementary Schools," by J. H. Gladstone, Ph.D., F.R.S., November 29, 1889; also to the discussions on these papers. Prof. Silvanus P. Thompson read a paper on "Secondary and Technical Education" before the same Society, in February of the present year, in which the educational scheme of the Charity Commissioners, as propounded in virtue of the Act of Parliament of 1883, was rather severely criticised (see *London Engineering*, February 21, 1890).

This subject might be almost indefinitely prolonged. It is one of great and increasing interest, and the more it is studied the greater the accumulation of material. Educational questions are now being discussed everywhere, in all countries, with a vigor as never before. Public interest has been aroused to the importance of the matter and to the necessity of modifications and improvements in the methods of teaching and of subjects taught. The examples and information presented in these papers are not intended as much to serve as models, as to show what is being done in other places, for if improvements are to be carried out in our own systems of education, it is advisable that we study what is being done elsewhere, and avail ourselves of the experience there gained.

It is possible that the writer may be able to furnish supplementary papers on this topic from time to time as

may seem advisable, and he should be glad to see contributions from others.

Why cannot such Institutions as the FRANKLIN INSTITUTE, the Builders' Exchange, the Pennsylvania Art Museum, the Philadelphia Exchange for Women's Work, and others of kindred interest, form themselves into an organization and do work such as is being performed by the City and Guilds of London Institute and the Department of Science and Art in Great Britain, to advance the cause of trade and technical education? These organizations could elect delegates to come together for the purpose of discussing, advising and advancing this question, the representatives appointed from each body forming a "Department for the Promotion of Education in Pennsylvania." The special interest of the FRANKLIN INSTITUTE would be in technical and science classes, and in the promotion of the mechanical arts; that of the Builders' Exchange in the trades classes; that of the Pennsylvania Art Museum in art and design; that of the Philadelphia Exchange in special classes for women's work, etc.

The FRANKLIN INSTITUTE is now in a position with its Board of Trustees to receive funds in trust for special purposes of education and for awarding of prizes, premiums, scholarships, etc., and these trusts can be carried out in the names of the donors. Grants of state aid can be made for certain departments of education and some such organization as here suggested, if carefully and properly worked up, would become a great agent in the cause of technical and trades education.

THE METALLURGICAL ARTS AT THE PARIS EXHIBITION.

BY F. LYNWOOD GARRISON,
Delegate of the INSTITUTE.

[*Concluded from vol. cxxx, p. 125.*]

FIRMINY STEEL WORKS.

The exhibit of this company was one of the best of the steel works of central France. It contained a large number of iron and steel metallurgical products, some of which possessed peculiar interest, a series of cast irons were shown, some containing fifteen per cent. manganese, also chrome cast iron with twenty-five per cent. chromium; silicon-spiegeleisen with fifteen per cent. silicium and eighteen per cent. manganese.

Some of the products of the Rollet cupola furnace for refining iron were also shown. It is claimed that the iron made in this furnace contains but ·004 per cent. phosphorus. The so-called Rollet Process is essentially a remelting of pig iron with additions of iron ore, limestone and fluorspar in a cupola furnace. The Firminy Company have deservedly a high reputation for their excellent production of steel projectiles, axles, car and carriage springs, and particularly gun carriages. Agricultural tools are also extensively manufactured; a specialty is made of Siemens-Martin steel for rifle barrels, large quantities having been supplied for the famous Lebel rifle.

The Firminy Company claims to have been the first works in France to adopt the Siemens-Martin process. Eight furnaces are now in operation, about equally divided between acid and basic, the magnesite used in the latter coming from Styria. Since 1870, large quantities of this steel have been manufactured into heavy ordnance. An interesting series of samples of iron and steel united by the Verdee process and used for dies, shears, etc., were exhibited. By this process a steel face is cast upon a wrought-iron

body; the union of the two metals appears to be perfect, judging from the fractures.

Another specialty of this company is the manufacture of steel wire of exceptional tensile strength. They claim to be able to produce three-millimetre wire having a tensile strengh of 250,000 pounds per square inch. Some 2·7-millemetre steel wire exhibited was claimed to possess as much as 270,000 pounds per square inch. The Firminy Company were among the first to manufacture crucible steel shells, chilled and tempered, and recently they have acquired celebrity for their armor-piercing projectiles of chrome and tungsten steel. They claim to have special methods of tempering these steels, the details of which are kept secret. The exhibit contained a series of thirteen railroad tires of various sizes, the largest being nearly ten feet in diameter and weighing 1,540 pounds. Very large forgings are not made to any extent at Firminy, their largest hammer being only thirty tons; the comparatively small ones, however, which they make, appear to be excellent in every way. There is only one blast furnace at present in operation at Firminy, with a daily production of about ninety tons. The following are analyses of the ores used:*

Locality.	SiO_2.	Al_2O_3.	*CaO.*	*Fe.*	*Mn.*	*Ph.*	*S.*
Spiliazeza, Greece, .	2·0	—	2·2	35 0	19·5	0·03	0·02
Mokta el Hadid, Algiers, ...	6·0	1·0	1·0	58·5	1·5	0·03	0·02
Elba, ...	12·0	0·5	1·0	50·0	—	—	0·03

The following are analyses of the pig iron and spiegeleisen produced: †

	C.	*Si.*	*Mn.*	*Ph.*	*S.*
Foundry iron, ...	3·40	3·20	0·10	0·07	0·02
White forge iron, ...	3·20	0·40	1·02	0·07	0·07
Silico-spiegeleisen, ...	1·42	17·00	18·09	0·085	trace
Spiegeleisen, ...	4·00	4·50	15·00	0·07	0·01

COMMENTRY—FOURCHAMBAULT COMPANY.

These works belong to the central or Loire group. The company has a capital of 25,000,000 francs, and, like many of the other large establishments of the kind in France, was

* *Journal of Iron and Steel Institute*, November 2, 1889, p. 394.

† *Ibid.*, p. 395.

built up by combining a number of small concerns. The works are divided into two principal groups, the collieries and the metallurgical establishments. The latter consist of the blast furnace and foundries of Montlucon (Allier); the forges and wire works of Fourchambault (Nièvre); the steel works of Imphy, and the Fourchambault and Nevers construction works. There are six blast furnaces at Montlucon, producing over 50,000 tons per year, which pig iron is celebrated for its purity and general excellence.

The Fourchambault Wire Works were established in 1818, by the Boigues family; they produce from 3,500 to 4,000 tons of wire per year.

The fifteen-ton open-hearth (Siemens-Martin) furnaces, located at the same place, are three in number, and produce about 20,000 tons of steel per year.

The Imphy Steel Works contain three open-hearth and two crucible furnaces, with hydraulic cranes for handling ingots, etc. The entire production amounts to about 12,000 of ingots and 1,500 tons steel castings per year. These works were the first in France to develop the production of steel castings. The Imphy Works are celebrated for wagon springs and for most of the higher grades of various kinds of steel. The display which this company made at the Exhibition was particularly complete and illustrative of its productions. It was divided into three classes—metallurgical products, illustrations of the working of their mines, and models, etc., of public works (travaux publiques), for which this company had supplied material.

MARREL FRÈRES (Rive-de-Gier Works).

These works, located on the Loire, were specially laid out for the production of steel in large masses. They have cast ingots up to eighty-five tons in weight and claim to be able to cast them up to 140 tons. A new 100-ton hammer is about completed at these works, the principal dimensions of which are as follows:

Weight of the falling mass,	100 tons.
Weight of the anvil block,	800 tons.
Maximum height of fall,	6 metres.
Steam cylinder diameter,	2 metres.

This steam-hammer will be used with two 180-ton steam cranes and two others of fifty tons each. It is established in a large shed, in which there is already working a fifty-ton steam-hammer, along with 100-ton cranes.

The furnace plant consists of four thirty-five-ton open-hearth furnaces, from which are produced the large ingots for the manufacture of guns, armor plate, etc. They also have a crucible steel plant, and produce considerable quantities of chrome steel.

ST. LOUIS-MARSEILLES IRON WORKS.

This company is one of the largest and most important in the south of France. It has long been celebrated for the production of superior foundry and forge pigs, spiegel-eisens, ferro-manganese, silico-spiegel (up to fourteen per cent. silicon), ferro-silicon (up to fourteen per cent. silicon), and ferro-chromium.

The following analysis is of the ferro-manganese, made by this company:

	Per Cent.
Iron,	6·23
Manganese,	85·40
Silicon,	0·466
Combined carbon,	7·100
Graphitic carbon,	0·560
Sulphur,	trace
Phosphorus,	0·165
Copper,	0·060
	99·984

Ferro-silicon (made in blast furnaces of the above company):

	Per Cent.
Iron,	82·60
Manganese,	2·50
Silicon,	12·60
Combined carbon, Graphitic carbon,	2·10
Sulphur,	0·054
Phosphorus,	0·088
Copper,	trace
	99·942

Ferro-chrome (made in blast furnaces of the above company):

	I.	*II.*
Chromium,	61·23	35·97
Iron,	30·17	57·28
Manganese,	1·35	1·20
Carbon,	6·07	4·21
Silicon,	1·11	1·21
Phosphorus,	0·05	0·03

It seems that it is very difficult to obtain these alloys containing over sixty-five per cent. chromium in blast furnaces; the richer ones are usually made in crucibles. Messrs. Holtzer & Co. have obtained some with as much as eighty per cent. chromium and eleven per cent. carbon in this manner.

LONGWY IRON AND STEEL WORKS.

These works, one of the most important in the eastern district (Meurthe-et-Moselle and Luxemburg) were established under their present management in 1880, with a capital of 15,000,000 francs, afterwards increased to 20,000,000. The Longwy Company has a number of different establishments, including the three blast furnaces of Mont St. Martin, the three blast furnaces of Prieuré, the basic Bessemer steel works at Longwy, and one or two smaller establishments. The works, as a whole, cover an area of thirty-nine acres, and have, besides, important concessions in iron ore properties. The company own the Mont St. Martin, Herserange, Moulaine and Valleroy mining tracts, and have an interest in those of Hussigny and Godbrange. Besides the ore from their own mines, the company use a certain quantity of Luxemburg and Bilbao ore to produce special grades of foundry iron. In making basic pig, ores from different sources are used. The following analyses are averages of a large number of samples taken on delivery at the furnaces.

	Iron.	Manganese	Silicon.	Lime.	Alumina.	Sulphur.	Phosphorus.
Longwy—							
Hussigny red,	39	0·20	12·5	8	7	0·20	0·7
Herserange,	38	0·15	13	9	6	0·30	0·7
Godbrange,	37	0·15	15	9	7	—	0·6
Coulmy,	42	0·25	17	4	7	—	0·6
Hussigny lime,	28	0·15	10	22	5	0·25	0·5
Herserange lime,	26	0·15	10	24	5	0·25	0·5
Luxemburg—							
Sauvage,	42	0·15	13	6	7	—	0·5
Rumelange gray G,	35	—	8	14·5	7	0·05	0·7
Rumelange gray W,	34	—	8	15·5	6·5	0·10	0·6
Rumelange gray K,	33	—	8	17	6·5	0·10	0·6
Rumelange gray P,	34·5	—	8	16	6	—	—
Rumelange gray B,	33	—	8	17	7	—	—
Rumelange yellow K,	38	—	5	13	5	0·15	—
Schifflange yellow S,	29·5	—	9·5	22·5	2	0·15	—

The following table gives the principal data of Longwy Company's blast furnaces. The first three are the Mont St. Martin, the next two the Prieuré furnaces, the sixth the Longwy, and the seventh the Moulaine furnace.

Blast Furnaces.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.
	ft.	*ft.*	*ft.*	*ft.*	*ft.*	*ft.*	*ft.*
Height,	61·0	60·0	59·5	62·2	62·2	72·2	60·7
Diameter at top,	15·1	13·4	12·3	15·1	15·4	15·4	9·2
Diameter at bosh,	21·3	16·1	18·0	19·7	19·7	23·0	16·7
Diameter at crucible (high),	10·5	9·8	7·2	8·0	8·0	8·2	8·2
Diameter at crucible (low),	8·2	9·8	4·9	7·4	7·4	8·2	8·2
Contents in cubic feet,	13·420	9·040	9·465	12·290	12·290	16·950	8·617
Hot blast stoves — C=Cowper; W=Whitwell,	5 C	4 C	—	3 W 1 C	4 W	6 C 4 lar. 2 sm.	Cast-iron pipes.
Number of tuyeres,	4	4	4	4	4	4	—
Pressure of blast in mm. of mercury,	11-12	10-11	—	10-11	10-11	11-12	—
Temperature of the blast,	—	1370° to 1480° F.				—	—
Daily production of basic iron in tons,	75	55	—	60	60	80	—
Date when furnaces were put in blast,	1880	1887	Out of blast.	1885	1884	1889	Out of blast.

The limestone used for the furnace is obtained from Saint Charles and Bellevue, the former carrying 2·5 per cent. silica and three per cent. of alumina, the latter four per cent. silica and 3·25 per cent. alumina, both containing about fifty-two per cent. of lime. The Mont St. Martin blast furnaces have been specially adapted for the basic process. The following are analyses of the different grades of pig iron produced by these furnaces:

Grade.	Manganese.	Carbon.		Silicon.	Sulphur.	Phosphorus.
		Comb.	Graph.			
Special foundry No. 1,	1·30	3·20	0·40	2·70	0·02	0·09
Special foundry No. 2,	1·10	3·05	0·50	2·50	0·04	0·07
Special foundry No. 3,	0·90	3·00	0·60	1·80	0·06	0·06
Special foundry No. 4,	0·85	2·50	1·30	1·40	0·09	0·06
White basic,	1·50	3·00		0·20	0·04	2·00
Mottled basic,	2·00	3·20		0·35	0·02	2·20

The analyses of the last two samples (basic pig) are interesting, as they are supposed to combine all the elements which constitute an ideal basic pig, viz: low silicon, very low sulphur, high phosphorus, and a moderate amount of manganese. The following analyses of the slag obtained from these furnaces will be of interest in this connection:

	Silica.	Alumina	Protoxide of Iron.	Protoxide of Manganese.	Lime.	Sulphur.
Vitreous basic,	32·5	16·5	1·4	1·6	46·0	0·8
White basic,	31·4	14·4	0·9	1·1	50·0	1·1
Yellow basic,	31·5	14·9	2·6	1·5	48·5	1·3
Black basic,	32·2	15·0	3·0	2·4	45·0	1·4
Foundry,	33·0	17·0	1·3	—	46·5	—
Foundry,	34·0	14·0	1·3	1·0	47·0	—

The pig iron is conveyed direct, while still liquid, to the basic Bessemer converters, which are located between the blast furnaces and the principal rolling mill. The three fifteen-ton converters are arranged around the same pit and are served by the same central casting crane, assisted by three primary and two secondary ingot cranes. The daily output of the three converters is from 250 to 300 tons, or a weekly production of from 6,000 to 7,000 tons. The basic linings of the converters last from 160 to 170 blows, the plugs from sixteen to twenty-five blows. The dolomite is calcined in three cupolas with natural draught, the firing lasting eight hours; the whole charge of the cupola is drawn at one time. From sixty to seventy tons of basic slag are poduced daily, carrying from fifteen to 16·5 per cent. of phosphoric acid. It is ground and sold as a fertilizer for

about thirty-five francs per ton at the works. The dolomite used for the basic lining is obtained from Ciney and Liége, the former containing about 0·8 per cent. silica, two per cent. alumina and iron, and ninety-six per cent. lime and magnesia, the latter 1·5 silica, 2·3 alumina and iron, and ninety-four per cent. lime and magnesia.

The following diagram (*Fig. 20*) shows the order of the elimination of elements in the pig under treatment in the basic Bessemer converters. The next diagram (*Fig. 21*) shows the composition of the slag during the operation.

The Longwy Company has adopted a scale of grades for their steel, and publishes the following table of tests and analyses to show the quality. The tests are made with round forged bars, sixteen millimetres in diameter, of 100 millimetres in length, the analyses being approximate averages:

Scale.	Tensile Strength. Kg. Per Sq. mm.	Elongation. Per Cent.	Manganese.	Carbon.	Phosphorus.
No. 1, hard, ...	75 to 70	12 to 14	0·1 to 1·2	0·3 to 0·35	about 0·1
No. 2, hard, ...	70 to 65	14 to 16	0·85 to 1·0	0·26 to 0·3	about 0·1
No. 3, medium, ...	65 to 60	16 to 18	0·7 to 0·85	0·22 to 0·26	about 0·1
No. 4, medium, ...	60 to 55	18 to 20	0·6 to 0·7	0·18 to 0·22	about 0·1
No. 5, soft, ...	55 to 50	20 to 22	0·5 to 0·6	0·15 to 0·18	—
No. 6, soft, ...	50 to 46	22 to 24	0·6 to 0·8	0·10 to 0·12	0·08 to 0·01
No. 7, very soft, ...	46 to 42	24 to 26	0·4 to 0·6	0·09 to 0·1	0·08 to 0·01
No. 8, extra soft, ...	42 to 38	26 to 28	0·25 to 0·4	0·08 to 0·09	0·05 to 0·08
No. 9, special, ...	under 38	over 28	0·25 to 0·3	0·08	0·03 to 0·05

The ingots made at Longwy are taken direct to the rolling mills, of which there are several. The appliances include a universal rolling train with rolls twenty-nine and one-half inches in diameter, also a train of three high rolls. There is a train of reversible twenty-six inch rolls, driven by a 2,500 horse-power engine. There is a fifteen-ton steam-hammer in the same building, with a reheating furnace, and crane for handling the ingots.

The reheating furnaces are worked in connection with vertical boilers, heated by the waste gases. The works are lighted by electricity. A testing machine of 100 tons, of the Marié type, is employed for flexion and traction tests, and another machine of the Trayvou type is employed for compression and other tests.

PONT-À-MOUSSON (Meurthe-et-Moselle).

These are one of the most important smelting works in the east of France; they have four blast furnaces, each making about forty-five tons of foundry pig daily, the most of which is made on the spot into pipe. The pipe foundry is one of the largest of the kind in France, having twenty-five vertical casting pits, and capacity for making nearly

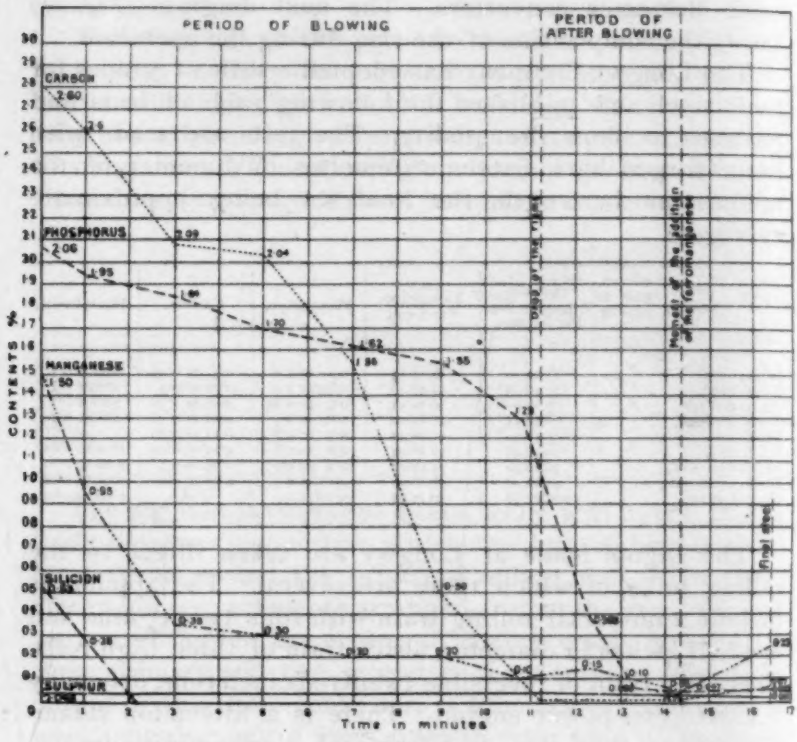


FIG. 20.

two miles of pipe per day, varying from 1½ inches to 6 feet in diameter and 13 feet in length. An example of the largest work was shown at the Exhibition, in the form of a socketted T-pipe, 13 feet long and 6 feet internal diameter in both limbs, which were moulded without a pattern and cast vertically.

The Pont-à-Mousson Company is one of the most flourish-

ing concerns in France. It was established in 1856 by Mansuy & Co., with a paid-up capital of 1,600,000 francs, and in 1886 was formed into a company with a capital of 2,047,500 francs. It is stated that since their foundation some 6,000,000 francs have been spent on the works, the greater part of which was drawn from the profits. In 1888, the total length of cast pipe produced was 547 miles, about

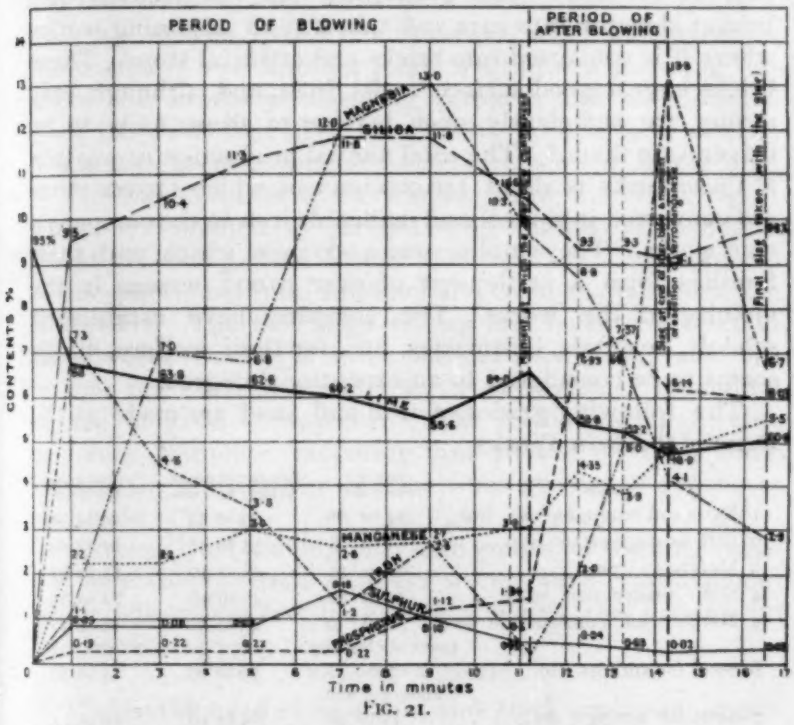


FIG. 21.

one-fourth of which was exported. The whole plant gives employment to over 1,300 men.

DENAIN AND ANZIN COMPANY.

The works of this company are located in the northern district near Valenciennes. They consist of ten blast furnaces and two Bessemer plants of two ten-ton converters each besides numerous puddling and reheating furnaces. Four of the blast furnaces were represented by models at the Exhi-

bition. They have Whitwell stoves, and pneumatic hoists for ore and coke. The most interesting part of these furnaces is the device for getting rid of the slag, which is granulated by running it into a large semi-circular basin placed in front of the furnaces, which receives the waste water from the tuyeres and other cooling appliances. The basin is divided by a middle wall, so that one-half is allotted to each pair of furnaces. The granulated slag is removed by a bucket elevator into cars and taken to an adjoining works, where it is converted into bricks and artificial stone. These bricks have a good surface, resist frost, and, although very strong, are sufficiently open texture to allow nails to be driven into them.* The total annual production of pig-iron at these works is about 150,000 tons, of which 120,000 tons are converted into steel and malleable iron in the company's own works. They employ over 4,000 men, which, with their families, form a settlement of over 10,000 persons in the vicinity of the works. The company have established schools, hospitals, infirmaries, etc., for their welfare, which seems to be considered to an exceptional degree.

The following grades of iron and steel are made at the Denain & Anzin Works:

Grade.	*Carbon. Per Cent.*	*Tensile Strength. Kilogs. per mm.*	*Elongation.† Per Cent.*
1 Extra soft homogeneous iron,	·04 to ·06	33 to 35	29 to 31
2 Soft homogeneous iron, . . .	·06 to ·08	35 to 37	27 to 29
3 Merchant iron, ...	·08 to ·12	38 to 40	25 to 27
4 Soft construction steel, . . .	·15 to ·20	42 to 46	22 to 25
5 Medium soft construction steel,	·20 to ·30	45 to 50	18 to 22
	Limit of elasticity,		
6 Steel for springs, etc., ...	39 to 41	59 to 62	15 to 20
	kilog. per mm.		
7 Steel for springs, etc., ...	45 to 48	65 to 70	10 to 15
8 Extra hard tool steel, ...	—	70 to 80	8 to 10

VALENCIENNES WORKS (Nord).

The foundries, forges and steel works of Valenciennes, in the Department of the Nord, are situated between the Escaut and the line from Valenciennes to Cateau. They cover an area of more than 60,000 square metres. Some

* *Engineer* (London), November 8, 1889, p. 387.

† Calculated on a bar 200 millimetres long.

60,000 tons of steel are annually produced by the Bessemer and the Siemens-Martin processes of manufacture. The works employ 1,500 hands, and are fitted with steam-hammers of fifteen, ten and three and one-half tons, respectively, a rolling-mill for the production of plates, a reversing rolling-mill, rail-testing machinery, foundries, a forge with twenty-eight puddling furnaces, twelve reheating furnaces and four trains of rolls, capable of producing 50,000 tons of iron per annum. At Trith-St.-Léger, near Valenciennes, the company own another forge, with fifteen puddling furnaces and auxiliary reheating furnaces and rolling-mills. They have also four blast furnaces at Jarville, near Nancy, where they produce annually about 100,000 tons of pig iron.

The Valenciennes Works use the oölitic ores of Chavigny, which are smelted at Jarville, some addition of manganiferous ore being made in the blast furnace. A proportion of phosphoric pig from England and Germany is used in the converters. The new large rolling mill recently erected at these works consists of three pairs of twenty-four-inch rolls in one line, driven directly by a two-cylinder horizontal engine of 5,000 horse-power. The feeding arrangements are very complete, including line rollers on both sides, carriers for shifting the blooms from groove to groove at each pass.

Sixteen Gjers soaking pits, with cranes for working same, are now in operation at these works, this establishment being one of the few in France in which the soaking pit has been adopted.

NEW PROCESSES.

Under the head of new iron and steel processes, or perhaps, to speak more exactly metallurgical devices, which have been introduced in France, within the last ten years we might place three. The Valton-Rémaury system of chrome iron-ore linings for open-hearth furnaces, the so-called Robert process and the Rollet process for producing purified castings. The Robert process, however, can only be called new by courtesy, for to any one familiar with the development and early history of the Bessemer process, it is evident that it is simply a resurrection of one or more of

the ideas and methods used by Bessemer in developing his process as it now exists.

CHROME IRON-ORE LININGS.

The use of these ores as neutral linings for open-hearth furnaces seems to have been experimented with in several of the works on the Continent and in England for a number of years past. The works of Bell Bros., at Port Clarence, near Middlesborough, England, appear to have gone into the thing rather more extensively than elsewhere, but with what results I have been unable to determine.

The ore is first roasted, then made into bricks or else broken into lumps (none larger than about three inches in diameter), which are bound together with lime mortar. Such bricks are very expensive, but last a long time, and, it is claimed, in the long run, are much more economical than dolomite linings. Bricks, however, need not be used, as the hearth and sides of the furnace can be lined with a mixture of three parts chrome iron-ore and one of lime, as free as possible from silica. The chrome ore should be as rich as possible, containing from forty to forty-five per cent. of Cr_2O_3.*

It is claimed that this lining resists equally well silica and silicious slags and remains neutral to strong bases. At the Putiloff Steel Works near St. Petersburg, Russia, it was found that the chrome-ore linings did not work well unless covered with a layer, about two inches thick, of dolomite or quartz; the dephosphorization being effected by this means and by the use of lime or dolomite fluxes. It is stated† that in the Finnish and Russian open-hearth steel works chrome-iron ore beds are no longer used, as it was found that the larger lumps broke away from the material composing the furnace bed and rose through the molten metal, thus causing the bed to wear away rapidly. This breaking away of the larger lumps does not take place at once, but only after the furnace has been in operation some time. On the other hand, Rémaury claims that one furnace at Alais,

* *Iron* (English), September 30, 1887, p. 304.

† *Journal of the Iron and Steel Institute*, No. 1, 1889, p. 341.

in France, has been running with the same bottom for three years.

At the Port Clarence Works (Bell Bros.) the charges, I understand, consist of ten tons of pig iron, three tons of iron scrap and two tons of steel scrap, to which afterwards limestone and iron ore are added. After melting from two to five hours, the slag is tapped off, carrying with it about fifty per cent. of the phosphorus. More iron ore is then added. The time required to convert one charge varies from nine and one-half to ten hours. From 0·7 to 0·8 per cent. of ferro-manganese is added in the casting ladle. It is claimed that the steel thus produced contains only from 0·02 to 0·04 per cent. phosphorus—a small amount of chromium seems to be taken up by the steel. The pig iron used averages about the following composition: Carbon, 3·6; silicon from 1·8 to 2·5; phosphorus, from 1·5 to 1·6; sulphur, 0·02 to 0·06, and manganese, 0·5 to 0·6 per cent.

ROBERT–BESSEMER STEEL PROCESS.

The Robert converter, or, as I have termed it heretofore, the Robert-Bessemer converter,* is a slight, if any, modification of what was known as the Walrand converter, which was erected at the Stenay Steel Works (Meuse), France, in September, 1885.† The Walrand converter seems to have been successfully operated, for several years with both acid and basic linings, in a number of places in France and Germany. It was not, however, until given the name of Robert or Bookwalter steel process, that it attracted any considerable attention. As this converter is fully described in the above-mentioned paper, it will be unnecessary to give any details in this place, except to mention that the converters have a D-shaped cross section, are mounted on trunnions like a Bessemer converter (*Figs. 22* and *23*). The tuyeres are all in the same horizontal plane on the flat side of the converter, with their axes at various angles to its horizontal axis. The converters are mostly

* "The Robert-Bessemer Steel Process," *Journal of the Iron and Steel Institute*, No. 2, 1889, p. 266.

† *Journal of the Iron and Steel Institute*, No. 2, 1886, p. 659.

small—under three tons as a rule. *Fig. 24* (*plate*) shows the construction and plan of the Walrand converter used at Stenay in 1885. The only difference between this converter and the Robert seems to be the number and size of the tuyeres; in other respects, the two forms appear

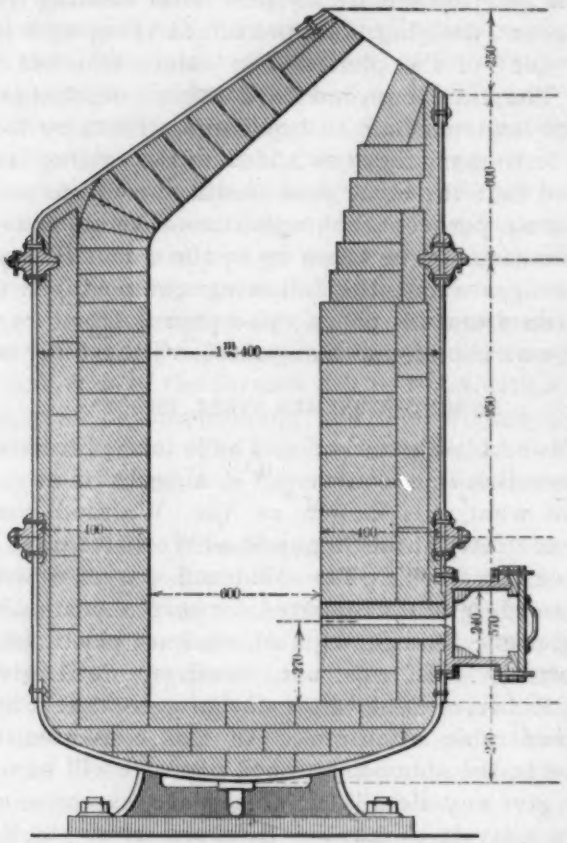


FIG. 22.—Robert-Bessemer Converter. (Vert. Section.)

to be identical. In the Walrand converter, the tuyeres are four in number, 3 inches wide by $1\frac{1}{4}$ inches deep, and are placed three or four inches below the surface of the metal bath. In the Robert converter, the tuyeres are more numerous, are round, with a diameter of about one and one-half inches, and placed just below the surface of the bath, so

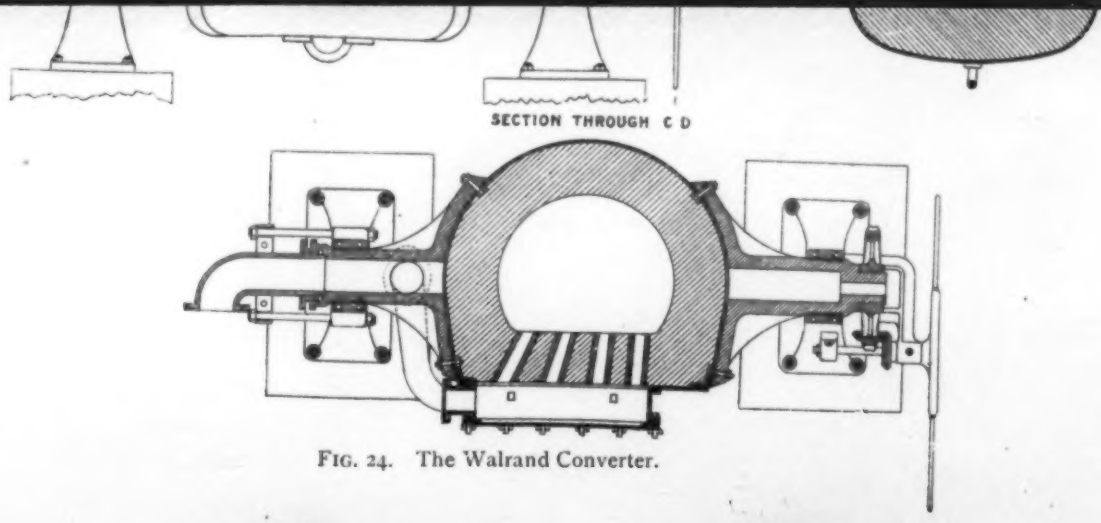


FIG. 24. The Walrand Converter.

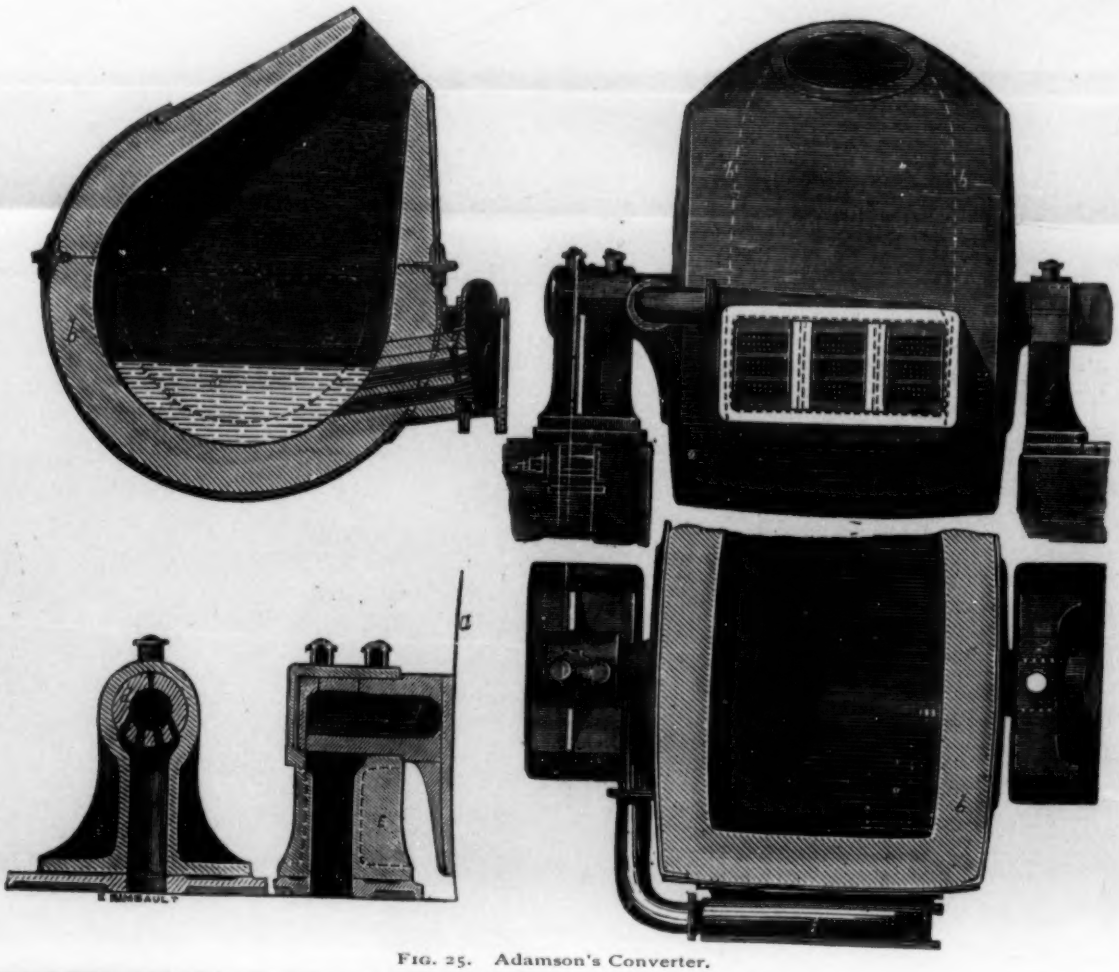


FIG. 25. Adamson's Converter.

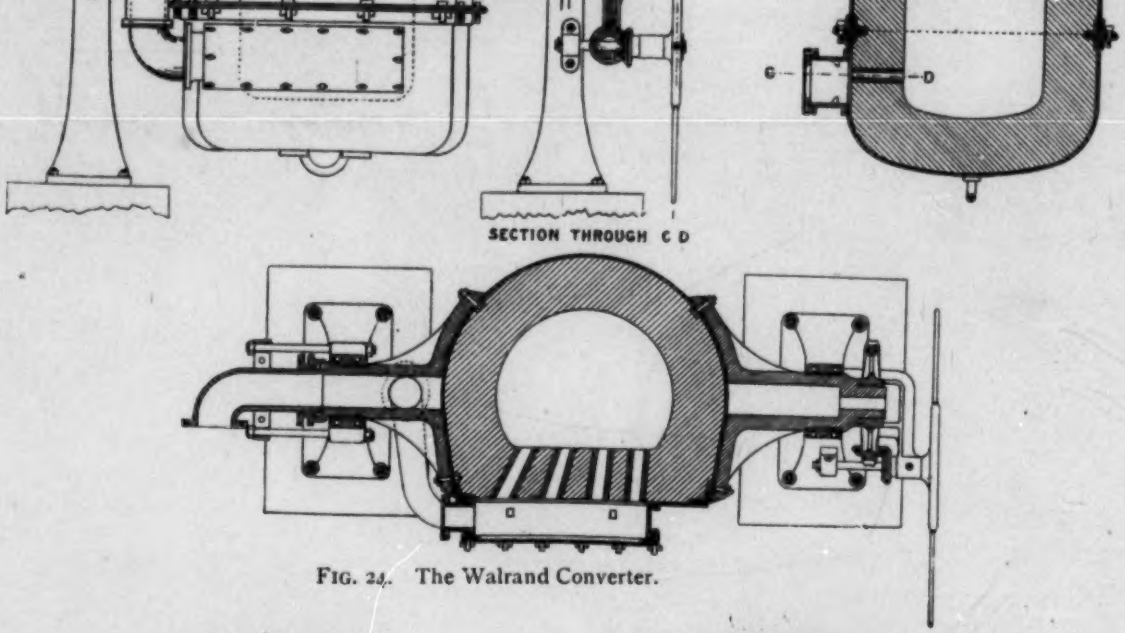
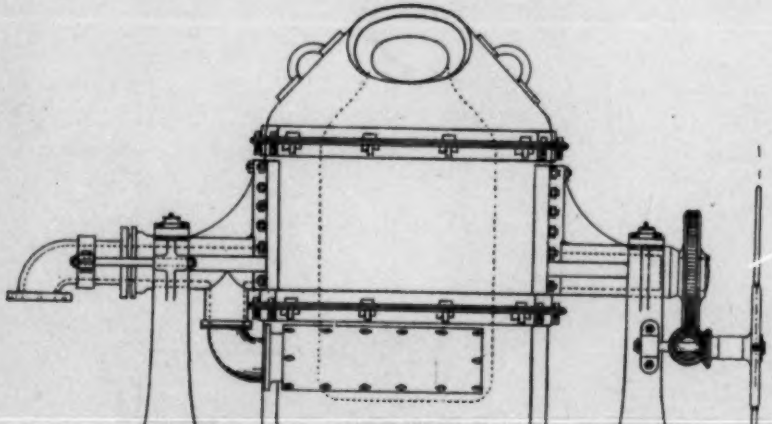
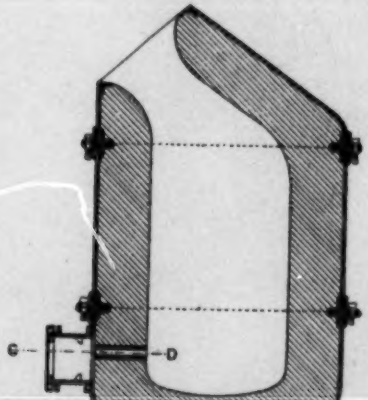


FIG. 24. The Walrand Converter.

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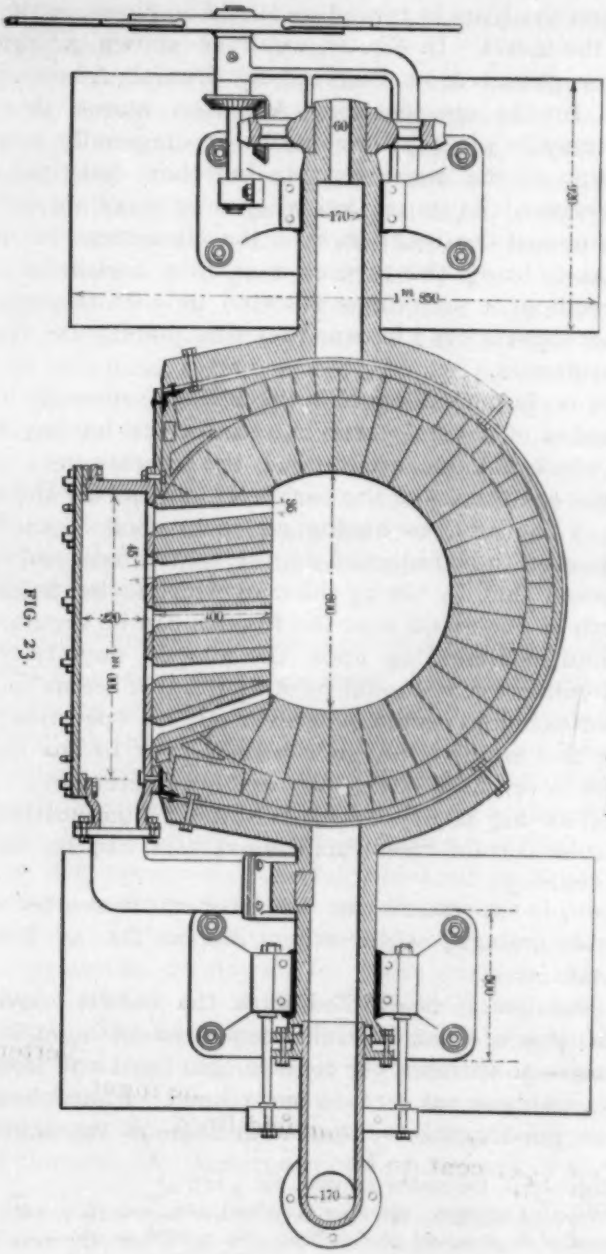

FIG. 23.—Robert-Bessemer Converter. (Plan.)

that when the blast is turned on it will impinge on the surface of the metal. In *Fig. 25*, we have shown a form of converter patented in England by Daniel Adamson in 1863*. In the specification, Adamson states that the tuyeres may be placed horizontally or diagonally towards the bottom of the converter. In another description of this converter, it is stated that when only small amounts of metal are used the inclination of the converter can be so varied as to bring the tuyeres near to a horizontal line.† This expedient is sometimes resorted to with the ordinary Bessemer converters; it can, therefore, hardly be considered uncommon.

What is claimed as novel in the Robert converter is "a combination of several parts in a converter having a flat side in which flat side are ranged the tuyeres in a plane horizontal to the axis of the converter, and all in the same plane." "The tuyeres having an inclination to enable a rotary motion to be imparted to the metal bath and being so disposed that by tilting the converter in the trunnions the depth of the metal over the tuyeres can be regulated."

Without commenting upon the alleged novelty of the Robert converter, it should be stated that it seems to have produced excellent results wherever put in operation; but whether this is due to any new principle or to any combination of several old ones, I am unable to determine. It is, however, as Sir Henry Bessemer states,‡ "unquestionably true that in certain cases small converters can be used to great advantage."

Some of the claims for the Robert converter seem reasonable enough, while others are, as far as I know, unsubstantiated.

For instance, it is claimed, with the Robert converter, that the loss of iron from the cupola to the ingot is only from twelve to thirteen per cent. in acid lined and from sixteen to seventeen per cent. in basic lined. I have heard it stated on good authority that with some of the acid-lined

* English patent, December 22, 1863, No. 3,233.

† Adamson's Converter, *Engineer* (London), 1864, vol. 18, p. 147.

‡ *Journal of the Iron and Steel Institute*, No. 2, 1886, p. 639.

converters used in this country this loss was reduced under ten per cent.

This is difficult to believe for several reasons, but chiefly to what appears to be an abnormal amount of *brown smoke* produced during the blow. M. Gautier states that in France, with small converters, no one could make a ton of steel with less than twenty per cent. waste of pig iron.* In small converters the oxide of iron has not time to burn the other elements, so it goes off in red or brown smoke, hence the greater waste. The exceptionally high temperature which is obtained in the Robert and in all small converters is due to a great extent to the extra oxidation (burning) of the iron. "It is a practical fact that the weight of pig iron required to make a ton of steel in small converters was much more than that required in a converter of the ordinary size.† It is claimed that the Robert is the only side-blown converter which is suitable for the basic process, as the large amount of slag produced would soon choke up a similar fixed converter.

ROLLET PROCESS FOR PRODUCING PURIFIED CASTINGS.

The process of fining castings, as here described, is intended to be auxiliary to the manufacture of special qualities of steel, its object being to eliminate sulphur, phosphorus and silicon from the castings. It consists in melting castings or pig, or maintaining them at a very high temperature under a double action, slightly reducing and slightly oxidizing, in the presence of a slag obtained by admixtures of limestone or lime, iron ores and fluorspar, in proportions depending on the quality of the pig or castings employed. The apparatus employed for this purpose, *Fig. 26*, is a blast furnace or modified cupola, using coke and a hot blast. The burdens are introduced in the same way as in blast furnaces and cupolas. It consists of a part *A*, an independent shaft *C*, several rows of tuyeres *FFF*, a siphon arrangement *SS*, for separating metal from slag, and of a front chamber *M*. Externally, it is composed of sheet iron

* *Journal of the Iron and Steel Institute*, No. 2, 1886, p. 673.

† Gautier, *Journal of the Iron and Steel Institute*, No. 2, 1886, p. 673.

and steel; internally, at the bottom, it is lined with any suitable refractory material, preferably with magnesia. It is cooled externally at all parts liable to injury by currents of cold water. The tuyeres are arranged in several rows, above one another. They are water tuyeres and project into the furnace. The hearth is situated as near as possible to the lower row of tuyeres. A single hole *K*, serves for tapping both the metal and the slag. In tapping, the metal is separated from the slag by means of the siphon, *SS*, which is so arranged in relation to the hole *QO*, as to prevent the blast from blowing through. The metal flows out at *LSS*, and the slag at *QO*. The tuyeres are arranged in several rows, to facilitate the melting of all the substances charged. They are arranged one above the other, so as to raise the temperature along a line passing in front of their nozzles, and so ensure a good working. They project inwardly, so that their ends may not get clogged by the colder and more decarburized matters which descend along the walls. The approximation of the lower row of tuyeres to the hearth is intended to prolong the action of the blast upon the slag, which at that point is light and frothy, and upon the metal which flows down through it, so as to ensure a greater elimination of phosphorus. The separation of metal from slag, as soon as both are removed from the action of the blast, is carried out so as to prevent the phosphorus already eliminated from going back into the metal, a result which would be produced by the reduction of the phosphoric acid of the slag by the action of the coke and the metal. Another object of the separation is to prevent too great a recarburization of the metal. The temperature of the blast is as high as possible, viz: 400° at least, so as to ensure the good action of the tuyeres. These would otherwise get clogged by the slag, which is always very refractory and stiff, or by the decarburized metal which forms at their ends. The furnace being in operation, metallic iron is formed, by the action of the blast and the iron ore upon the cast iron or pig, on the bottom part of the walls, where it adheres, thus forming, after working twenty-four to thirty-six hours, a substitute for the original lining.

The furnace may thus be run for an indefinite period of time. But it will be preferable, after two or three months' working, to reline the upper portion, as the bricks will then

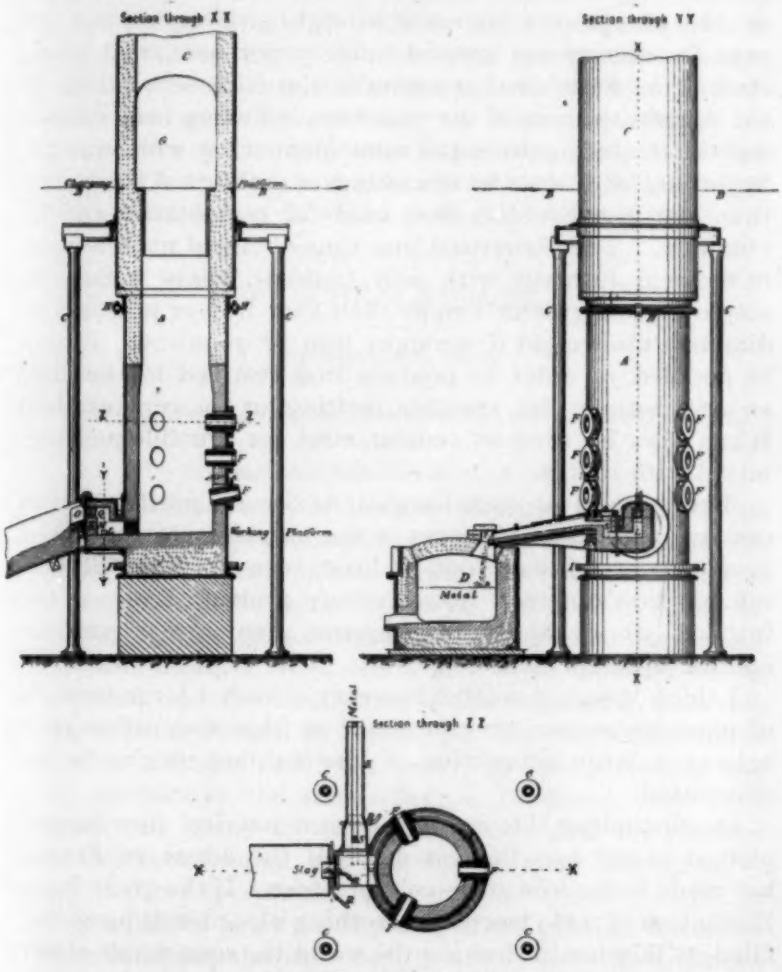

FIG. 26.—Rollet Cupola.

be worn out by attrition. The production is from fifty to seventy five tons per day of twenty-four hours. The product obtained usually has a white, spongy appearance. The slags are yellowish white. They contain almost all the

phosphorus eliminated from the cast iron or pig in the state of phosphoric acid, and only a part of the sulphur in the condition of sulphide. The elimination of the sulphur is complete up to ninety-nine per cent., and even more. That of the phosphorus amounts to eighty or eighty-five per cent., in exceptional cases to ninety per cent., and more. And as the recarburizing action of the coke sets a limit to the decarburization of the cast iron, a casting once treated may be treated again in the same manner, by which means, beginning with any sort of castings, a carburized iron purer than the best Swedish iron used for cementation can be obtained. The carburized iron thus obtained may be used in Siemens furnaces with acid bottoms, where it may be employed to a greater extent than cast iron or pig, and so diminish the weight if wrought iron be required. It may be puddled, in order to produce iron destined for melting on acid bottoms, for crucible melting, or for cementation. It can also be used as cement steel for crucible melting, mixed with iron.*

This process or metallurgical device for purifying iron castings appears to be as yet in but an elementary stage of development. I have not, at least, seen or heard of any reliable data obtained from a steady prolonged use of the furnace. It would therefore appear premature to pass an opinion upon its merits.

I think it very doubtful, however, if such a large amount of phosphorus can be eliminated in this way, although I believe a large proportion of the sulphur might be so eliminated.

In concluding this report I cannot but feel how incomplete it is and how little it shows of the advances France has made in the iron and steel industries. If the great Paris Exhibition of 1889 teaches us nothing else, it will have fulfilled its mission in showing the world the remarkable thrift and industry of the French people. France has had enough disasters within this century to have forever ruined any country similarly situated, and yet we see her to-day, while perhaps not so powerful and rich, as vigorous and enter-

* *Jour. Iron and Steel Institute*, No. 1, 1890, p. 154.

prising as ever. It is easy to understand how so small a country as England should be rich and powerful, for she has had no disastrous wars to sap the strength, and within her comparatively tiny borders are vast stores of coal and iron, to say nothing of the strong and vigorous race which develop and use them. The mineral resources of France, on the other hand, are, as far as we know, very much more limited, and as we have seen, a very large proportion of the coal and ores she consumes are imported. Truly, Helvetius has said, "*le bonheur des peuples dépend et de la félicité dont ils jouissent au dedans et du respect qu'ils inspirent au dehors.*"

PRECIOUS STONES.

By George F. Kunz.

[*A Lecture delivered before the* Franklin Institute, *February 17, 1890.*]

[*Concluded from vol. cxxx, p. 182.*]

The families with iridescent interior layers are the following: among the cephalopods, the nautilus and the ammonites, the latter wholly fossil. In both these groups the removal of the outer layers of the shell reveals the splendid pearly surface beneath. Modern nautilus shells are often "cleaned" with dilute acid to fit them for use as ornaments, and frequently this is done partially, elaborate patterns being formed by leaving parts of the white middle layers to contrast with the pearly ground. Among the fossil ammonites, the same effect is produced, very often naturally by decay of the outer layers; and no artificial pearl work can equal the richness of color displayed by many of these specimens.

The subdued beauty and purity of the pearl now renders it even more popular than before, and it never commanded such high prices as during the past ten years. At present no jewel is considered in quieter or better taste than the pearl. This unusual demand has had the effect of greatly stimulating the search for them, especially on the west coast of Australia, Thursday Island, the Sooloo Archi-

pelago, in Ceylon, and the Persian Gulf, and also along the coast of Lower California.

The demand has included pearls of all colors except the inferior yellow. The fine black pearls from Lower California have been in great request, single ones bringing as much as $8,000. And with these black pearls are found many beautiful gray and grayish-brown ones. The different fisheries of the world produce fully $1,000,000 worth annually, of which our Lower California fisheries have yielded fully one-sixth. Kentucky, Tennessee and Texas have given us over $10,000 worth of pearls per annum, derived from the fresh water unios, and during 1889 at least $30,000 worth of pearls were found in one district in Wisconsin, many of which were remarkable for their brilliant and curious tints, red, purple and metallic.

The subject of artificial gems is at present of considerable interest, as furnishing an example of the surprises which the modern science of chemistry is constantly giving us. In 1886, there appeared in the Paris market certain stones which had been offered for sale by a Geneva house as rubies from a new locality; subsequently it was said that they were obtained by the fusion of a large number of small rubies, worth at most but a few dollars a carat, into one gem worth many times that amount. An examination proved that they were not the product of fusion, which would have resulted in the formation of a substance lower in specific gravity and less hard than a ruby; but that they were artificial stones, and had been formed by heat, not from rubies, but evidently from passing an aluminate of lead in connection with silica into a silicious crucible, the silica uniting with the lead to form a lead silicate, and liberating the alumina, which crystallized in the form of corundum. The difference between these stones and the true ruby was very apparent, owing to the presence of a large number of spherical bubbles, occasionally some pear-shaped, and a stringy internal structure, showing how the bubbles had moved. Mr. Ebelmann, at Sèvres, over forty years ago, and now M. Fremy, of Paris, after fifteen years' experimenting, has, with the assistance of M. Verneuil, suc-

ceeded in obtaining large numbers of beautiful crystals, one obtained after many experiments, and conditioned largely upon the fire, which regulates chemical action. Although the color is excellent, the crystals do not exceed one-twenty-fifth to one-fiftieth of an inch in diameter.

In *Nature*, vol. xxi, January 1, 1880, p. 203, Mr. MacTear, of the St. Rollo Works, Glasgow, published some investigations, by which, he claimed, he had produced artificial diamonds. Prof. N. S. Maskelyne proved this claim to be unfounded, as has been the case with other investigators. In 1880, Mr. J. Ballantine Hannay read before the Royal Society a paper in which he claimed to have successfully produced artificial diamonds, after eighty dangerous experiments. He had obtained the results, he said, by tightly sealing steel and iron tubes or coils, about four inches thick (some of which were made by boring out a solid block of iron), containing ten per cent. bone-oil and ninety per cent. paraffine spirit.* After subjecting these tubes to intense heat, for some hours, he produced fourteen milligrammes of residue, part of which he called diamond. The substance exhibited before the Society was undoubtedly diamond, being pronounced such by Profs. Maskelyne, Roscoe, Stokes and others; but none of it can be seen today in the British Museum cabinet, and as the specimens were of a fragmentary character, and not crystals, it is believed by many that, although they were diamonds, they were never made by Mr. Hannay.

PARIS EXPOSITION.

Fifty-five nations were represented at the Paris Exposition, and nearly every one of these had a governmental exhibit of the minerals of its country, besides in many cases collective exhibits of private collectors. Some of these exhibits were very remarkable, and had they been assembled in one building, as was the machinery in Machinery Hall, the mineralogical and metallurgical and precious stones exhibits would have been impressive ones. As it was, they were scattered over such immense distances that important ones were often overlooked.

* [A part of the charge was an alkali metal.—ED.]

Class 41, which included minerals, or, in other words, the products of mining and the materials obtained therefrom, contained over 1,800 distinct exhibits. A collection of gold shown in this class by a French engineer, in the French Section, was perhaps the finest ever formed. It contained many remarkable specimens of gold from California; a wire of gold, six inches long, from Colorado; gold amalgam, nuggets and gold-dust. The 300 specimens represented almost every gold-producing country in the world, and the collection was the result of over thirty years' work.

In the centre of the French Jewelry Section, Class 37, was exhibited the Imperial or Victoria diamond, already described; at one of the four central corners, by Bapst & Falize, the historic Sancy diamond, weighing forty-one carats; opposite a necklace composed of pink, blue, yellow, brown, black and other colored diamonds. This section contained an immense number of fine and curious diamonds, rubies, emeralds and other precious stones, as well as several interesting lapidary exhibits, and nearly fifty exhibits of imitation stones of all kinds, imitation pearls, etc. A carved diamond turtle, a fly, and some curiously drilled diamonds were of more than ordinary interest.

In Class 18, Section of Decorative Arts, were some fine chandeliers of rock crystal, valued at $7,000 each; pedestals covered with slabs of *agate amethyst* from Lorraine, valued at over $2,000 a pair; rock-crystal spheres (not perfect however) up to six and one-half inches in diameter, and other magnificent examples of lapidarian work in agate, jasper, rhodonite and jade.

From the Pyrenees and from Belgium, magnificent collections of finely colored marbles were shown.

The Russian exhibit contained a case of nephrite and graphite, exposed by M. Alibert, similar to the collections shown at the Expositions of 1867 and 1878, which were presented by M. Alibert to the École des Mines, the Musée Naturel and the Conservatoire des Arts et Metiers. Jade was formerly obtained by M. Alibert in his graphite mines in Siberia, discovered in 1847 at Botovgal in the Sian Mountains, near the Chinese frontier. One mass of jade

from these mines weighs 1,300 pounds, another 1,100, and several of the specimens in the case weighed several hundred pounds each.

Of even more interest were the polished, transparent sections of boulders of jade, sawed by M. Alibert from blocks found by himself; these were beautifully polished on both sides, were less than one-eighth inch in thickness, and some measured 3 feet in length and over 18 inches in width, forming beautiful panes for windows having a delicate shading and a brilliancy not to be obtained in any other material. With this was a large series of graphite, curiously carved into ornaments, to show the perfect homogeneity and fine grain of the graphite from his mines.

The collection of Mr. Woerfel contained a large number of the table tops, mantels, vases and other ornaments of malachite, lapis-lazuli, rhodonite, labrador spar, and other stones characteristically Russian, which have been used extensively in that country in the decoration of churches and palaces, and have been frequently made use of as imperial gifts by the Czar, as the royal palaces throughout Europe will testify.

From the Ural Mountains came an exhibit of a magnificent series of blue, white and sherry-colored topaz crystals, some of the largest of which weighed one pound, and some smaller ones, several inches in length, were absolutely transparent; a doubly terminated crystal of beryl that weighed one pound eight ounces, but was not entirely free from internal fractures; small crystals of alexandrite; some magnificent purple amethysts, unrivalled for depth and richness of color; *chrome tourmaline* in crystals, from one to three inches in length, and other varieties of well-known Russian minerals.

In the Hungarian Section was a very interesting case of opals, and also opal in the trachyte matrix, from the famous Hungarian mines at Czernowitza, which have been worked for over 300 years.

In the Roumanian Section was exhibited a very interesting series of ambers, strikingly like those from Catania,

Sicily, in form and in color; the different colors shown were light yellow, dark yellow, cloudy white, opaque white, black, brown, bluish-green, dark opalescent blue, opaque red, of which Prince Bibesco loaned one of the finest known necklaces. This amber was all found in the department of Buzeo and in these places: Bisca-rusilei, Bisca-Chisjdului, Coltzia, Valea-boului and Bodila. The Roumanian amber is exceedingly rare and is very highly valued.

At the Exposition, there were three exhibits at which the branches of cutting and polishing were carried on. At the Holland pavilion, the display made by Boas Frères, of Amsterdam, had a number of polishing wheels, the motive-power of which was steam, as well as a machine reconstructed, showing the manner in which man-power was utilized during the eighteenth century. With this exhibit there was a large series, illustrating the various forms of cutting the brilliant, rose and table, as well as all the forms of rough diamonds, such as cleavages, splints, those for glass-cutting, and shaped for specially adapted tools.

Two Belgians exhibited diamonds—one perfect yellow octahedral diamond, weighing 300 carats; a diamond cross, cut from a single stone (which is not unique, as claimed by the exhibitor, for such a stone was contained in the Hope Collection and was illustrated in the Hope Catalogue of 1839); some fanciful and curiously-cut brilliants; a small sword cut out of three diamonds, and the name of the exhibitor in table diamonds, seventeen of which were nearly an inch in length.

In the main aisle, Coutermans, of Antwerp, had an exhibit with the polishing wheels, an exhibit of the diamonds in the altered kimberlite, and a black diamond, weighing thirty carats, which it was reported had been purchased by the Shah, but of which in reality he only inquired the price.

Greece made a magnificent display from the famous mines at Laurium, which were worked before the beginning of the Christian era, as is proved beyond doubt by the fact that, in the collection in the Assyrian Gallery, in the Louvre, the writer saw necklaces made of beads of gold and

carnelian, and also, to his surprise, of the blue and white-veined beads of so-called calamine (Smithsonite), from Laurium. Masses of this mineral were exhibited that must have weighed at least a ton each, and in the general exhibit were magnificent botryoidal specimens, from this locality, of the blue, green and yellow calamine, which rivalled anything found elsewhere.

In the Persian Section were shown masses of lapis-lazuli, weighing several pounds each, and a large series of cut and engraved Persian torquoises.

In the Madagascar Pavilion was exhibited a series of gravels containing sapphire, zircon and tourmaline.

A collection of precious and ornamental stones of North America, as well as a collection of foreign precious stones, was displayed by Messrs. Tiffany & Co., in the American Section. The former collection was contained in a circular case nine feet in diameter, on a platform erected at the intersection of the four aisles of the American Section. This collection was formed for the purpose of illustrating the occurrences of the precious and ornamental stones in North America, and contained many of the finest examples that have been found, some unique, others entirely new. This collection was the result of purchase, completed by generous loans from some of our prominent mineralogists, and was an object of interest to the many visitors of the Exposition.

One of the features of the jewelry exhibit was the utilization of American stones and pearls in jewelry, notably tourmalines, beryls (yellow, green and blue), rock crystals for vials and boxes, and pearls from the unios in a large variety of objects—the motive, as well as the materials employed, being American in character.

Among the more important things in this collection were some small diamonds from California; a series of the original crystals of sapphires, collected by Col. C. W. Jenks when he opened the Jenks Mine in Franklin, Macon County, N. C.—among them the first sapphire found in the United States; a ruby of fair color, some American crystals and cut topaz from Cheyenne Mountain, Col.; one of the largest

crystals of emerald from Alexander County, N. C., loaned by Mr. Bement; the cut aquamarine, weighing 133$\frac{15}{32}$ carats, from Stoneham, Me.; thirteen cut aquamarines from Mt. Antero, Col., found at an altitude of 14,000 feet above the sea; a number of cut spessartite garnets, one of which weighed 96$\frac{1}{16}$ carats, from Amelia Court House, Va.; a series of colored tourmalines, both cut and crystal form, from Mt. Mica and from Auburn Me.; a collection of pearls and the shells in which they are found on the shores and in the rivers and brooks of North America.

Some notable things in the Tiffany foreign collection were a series of twenty-four fancy colored sapphires, weighing from two to twenty carats, and showing every color of the spectrum, some fine alexandrites, chrysoberyls, and zircons from Ceylon; crystals and cut euclase from Brazil and Siberia, and a number of interesting precious and ornamental stones.

The Brazilian Commission exhibited a very interesting collection of the precious stones of Brazil, especially the diamond and its associations, but not such fine examples as those shown at our Centennial Exposition. Many of the fine specimens in this exhibit were loaned by European collectors and dealers. Among those of chief interest were a dish of yellow topaz crystals, several of which are over two inches in length and one inch in diameter; magnificent crystals of green tourmaline, from two and a half to four inches long; fragments of crystals of amethyst, two and three inches in diameter; diamond crystals, from less than the size of a pin-head up to six carats. There was also a collection of minerals associated with the diamond in Brazil, consisting of rutile, zircon, anatase, lazulite, and a set in miniature of the implements and bowls used in washing and in digging and working the river gravels. This entire case is the production of the province of Minas. Of special interest are the "Sables Diamantifères," as the conglomerate rock containing the diamond is called, and also the masses of klaprothine, identical with the lazulite of Georgia, and the series of minerals of the gravels which were identified by Prof. Gorceix, of the School

of Mines, at Oura Preta, among which were pyrope, cyanite, pyrite, fibrolite, xenotime, anatase, hematite, limonite, tourmaline, monazite, baierite (titanic iron) and itacolumite rock. These are especially interesting since they have all been found in North Carolina and Georgia. The Vicountess de Cavalacantie exhibited a case of jewels from the province of Minas, among which were some fine amethysts, topazes, aquamarines, citrines and five beautiful examples of the chrysoberyl or chrysolite jewelry worn and made in the latter part of the eighteenth century.

Among a remarkable series of ornaments made and worn by the Botocudo Indians of Brazil were some made of materials of marked mineralogical interest. The most notable were lip ornaments, one a rich Amazon-green feldspar in the form of a disk, 2½ inches in diameter and about 1 inch thick, with projecting shoulders for retaining the ornament in the lip. The great breadth of this would suggest difficulty in the use of a pipe; but Dr. Ladislaus Netto, Director of the National Museum, Rio de Janeiro, exhibited a pipe used by the Indians, adapted to overcome this difficulty. The stem was flat and over two inches in diameter and quite thin, so that it could be laid on the projecting lip ornament and easily held in the mouth. Another lip ornament was 3 inches long and 1½ wide; another an oval disk, 3½ inches long and 1 inch thick, of beryl; a flat, sole-like fish, 2 inches long and 1 inch wide, made of a material said to be jade; a circular shaft of rock crystal, five inches long, with two projecting ends; two spear-heads, three and four inches long, and some ear ornaments, all made of transparent rock crystal.

In the Bolivian Pavilion was also a series of specimens of lapis-lazuli from the Andes, to which were given four distinct names, *i. e.*, Lapis agatado, lapis-lazuli, lapis maclado, lapis laminosa. The most important exhibit was in the United Diamond Mines Building, in which every process connected with the mining and cutting of the diamond could be seen under one roof.

First the large sacks of earth, of which 1,000 were washed at the Exposition, were thrown onto a screen which

sifted the material into a large washing-pan, or "compound" as it is called, about fifteen feet in diameter. In this compound all the soft mud, light particles of shale, kimberlite, quartz, calcite and other minerals, whose specific gravity is less than that of the diamond, were floated out, and in the centre the diamond, garnet, pyroxene and heavier minerals were concentrated. These concentrates were then carefully sorted, the garnets and the diamonds being the only ones of value.

In connection with this exhibit were shown models, or rather reproductions, made of earth, and small models, exact duplicates of the machinery and the tunnel systems used at the mines.

The De Beers Consolidated Mines exhibited, in a large central case, 5,138 carats of rough diamonds. This case was securely covered with an iron cage, like a parrot cage in form, exposed by the maker of the cage in which the Kohinoor diamond was exhibited at the London Exposition of 1851. In this exhibit was a cut diamond, the largest brilliant in the world, weighing 228½ carats, which in the rough had weighed over 400 carats; one large octahedral crystal weighing 306 carats, and a collection of 983 carats of fancy-colored crystals of white, mauve, pink, orange, yellow, brown and black; also, a large number of distorted and curious crystals. The Belfontein Mine exhibited 11,227 carats of rough diamonds, and the Griqua Land West Diamond Mining Company a parcel of 45,003 carats.

At the opening of the Exposition the diamonds were valued at twenty-two shillings a carat, and at its close at thirty-eight shillings; so great has been the advance in the price of rough diamonds. One thousand sacks of diamond earth were washed at the Exposition, and the average amount of diamond found was one and one-half carat to a load of earth.

In connection with this exhibit was the cutting of diamonds, carried on by M. Roulina, who reintroduced diamond-cutting in France, and is one of the few men abroad who has utilized a machine for the process. This machine, however, is very primitive in comparison with the

more perfect one invented fifteen years ago in the United States and in use here since. There were also diamond-piercing machines in operation; these required from twenty to thirty days to pierce a diamond of about two millimetres in thickness, the drills revolving at the rate of 14,000 revolutions a minute.

Not without interest was a diamond which had been a beautiful white stone of about nine carats, but which was shattered into fragments while undergoing the polishing process on the wheel.

ON PHOSPHORESCENT DIAMONDS.

On November 4th, I was enabled to make an experiment, through the courtesy of Dr. E. Mascart, membre de l'Institut, Director of the Central Observatory of Paris, and Prof. B. Abdank, electrician, member of the jury, who arranged a dark room, in which a collection of over one hundred and fifty diamonds was placed. In one side of the wall was inserted a lens, and outside the room was suspended a new alternating arc lamp of the Thomson-Houston system. The lens, which served the purpose of concentrating the light, was covered with a violet-colored glass, so that only the ultra-violet rays were thrown on the diamonds, which numbered over 150 stones. Among these were several old Indian, Brazilian and Cape stones, and from the South Africa River diggings. Of the entire collection, only three diamonds were phosphorescent. One, a Brazilian stone of one and five-eighths carats, possessed this quality in a remarkable degree; an old Brazilian stone of three carats also showed the same property; all the others assumed a beautiful violet tint. The two stones whose phosphorescence was most marked were perfectly transparent white stones, one with a bluish tinge; they assumed the milky white color of the variety peculiar to the Bagagom mines of Minas Geraes, of which only a few are annually found. The phosphorescence exhibited by these stones was extremely beautiful, it remained visible when a metallic cap was put over the lens, gradually losing its intensity, however, for fifteen minutes after the exposure. All the other stones

collected were invisible in the dark. Pure white light was also used, resulting in a less beautiful experiment, though the phosphorescence was quite as apparent.

This test fully demonstrated the fact that some diamonds, though not all, possess the power of absorbing light, and emitting it in the dark; and in those possessing it, it is found in different degrees of intensity.

An experiment was also made to test perfection of cutting. Light from a common arc lamp was concentrated on the table of stone, from the facets of which spectra were reflected on the wall, the regularity of which depended upon the perfection of the cutting.

Dr. Crookes says: "Next to the diamond, alumina in the form of ruby is, perhaps, the most strikingly phosphorescent stone he had examined. It glows with a rich full red, and a remarkable feature is that it is of little consequence what degree of color the earth or stone possesses naturally, the color of the phosphorescence is nearly the same in all cases—chemically precipitated amorphous alumina, rubies of a pale reddish yellow and gems of the prized pigeon's-blood color glowing alike in the vacuum, thus corroborating E. Becquerel's results on the action of light on alumina and its compounds in the phosphorescope. The appearance of the alumina glow in the spectroscope is remarkable. There is a faint, continuous spectrum ending in the red somewhere near the line B; then a black space, and next an intensely brilliant and sharp red line, to which nearly the whole of the intensity of the colored glow is due, this suggesting that the colors in corundum gems may only be a change in the alumina, and not a definite coloring matter."

Considerable attention has been given to the alleged power of diamonds to emit light in absolute darkness. Dr. William Crookes, in his experiments on the phosphorescence of diamonds of various colors, found that those glowing pale blue had the longest residual glow. Next came the yellow. He was unable to detect any residual glow in diamonds of a reddish color. A large diamond of greenish hue, very phosphorescent, shone almost as brightly in the phosphorescope as out of it.

To the numerous allusions that have been made in the press to the exhibit of artificial stones at the Paris Exposition, is probably due the popular error that confounds the word "artificial" with the word "imitation." Not a single artificial diamond, ruby or sapphire was shown; but there were some hundreds of exhibits of imitation stones from France, Austria, Hungary and Germany. The term "artificial" can be correctly applied only to a gem that is artificially made; whereas, the term "imitation" covers all glass and such other productions.

COAL-WASTE COMMISSION.

The Commonwealth of Pennsylvania has appointed a commission, consisting of J. H. Price, E. B. Coxe and P. W. Sheafer, to consider the question of coal waste in the state of Pennsylvania. This commission has divided the subject into three heads, viz: Geological and statistical waste; Waste of producing and marketing, and Utilization of coal-waste. The circular-letter containing the above divisions and subdivisions has been addressed by the commissioners, together with a special letter, to a number of individuals and editors, in order to obtain on the subject every possible information. This action recalls the committee which was appointed by the American Institute of Mining Engineers, at its first meeting, held in Wilkesbarre, May 16, 1871, when R. P. Rothwell read a paper on "The Waste in Coal Mining," and, "at the conclusion of the discussion of Mr. Rothwell's paper, a committee was appointed, consisting of Messrs. E. B. Coxe, Thos. S. McNair, Daniel Hoffman, E. Gaujot, R. P. Rothwell and Wm. B. Hicks, to consider and report upon waste in coal mining."

Although Mr. Rothwell had opened his remarks by characterizing the inquiry as a subject "of the greatest possible importance to the industries we represent," and added, "it is a fact, which many of you can certify to, that we are wasting *fully one-half of all the coal in the veins* we are now working, and there are cases which might be mentioned where this proportion, immense as it is, has been greatly

exceeded;" with the exception of a preliminary report—(very preliminary)—sketching the method of going to work, at the Bethlehem meeting, in August of the same year, this committee never reported, though, from time to time, the subject came up; as in J. W. Harden's paper on the wasting of coals at the mines, in the Boston meeting of February 18, 1873, in the discussion of J. Price Wetherill's paper on "Anthracite Coal Mining in Schuylkill County," at the Philadelphia meeting of October, 1876, and, incidentally, in a paper by W. P. Shinn, on "The Advance of Mining and Metallurgical Art," at the Philadelphia annual meeting of February, 1881.

In fact, it got to be one of the perennial jokes of the A.I.M.E meetings to allude to the report of the Committee on Coal Waste.

The reason for the dilatoriness of this committee was never generally understood. Subsequently, in 1881, a report on coal waste (A2) was made by Franklin Platt, from the geological survey of the state; and a chapter was devoted to the subject by Dr. H. M. Chance, in report AC. (1883), under the general title of coal mining.

These, and several other treatises on the subject, have repeatedly called the attention of engineers to the reckless misuse of the bounties of Nature, but without the result of extinguishing the evil.

The results of the commission will be looked for with much interest, both by scientific men and consumers of coal.

The ability of the commissioners appointed is unquestioned. F.

THE PROCESSES OF STEAM IN ITS DEVELOPMENT OF POWER BY MEANS OF A STEAM ENGINE.

BY CHIEF ENGINEER ISHERWOOD, U.S.N.

[*A Lecture delivered before the Sibley College of the Cornell University, Ithaca, N. Y., December 13, 1889.*]

At the present stage of steam engineering, the most important research as regards the use of steam in steam engines to produce continuous mechanical power, is the investigation of the various processes of the steam from leaving the boiler to arriving in the condenser. No attempt, to my knowledge, has been made up to the present hour to ascertain the kind and value of these processes, to show the great influence they exercise on the potential and economic effect of the engine, and to determine in what direction and to what extent they affect the possibility of improvement. A knowledge of these processes will prevent a waste of effort in wrong directions, will prevent attempts to overcome imaginary difficulties while ignoring real ones, and will guide unerringly to all that is possible to be obtained, having regard to the limitations imposed by Nature and to which art must accommodate its labors if success is to follow them. Steam engineering, like all branches of industry, has a two-fold aspect: it may be practised as an art, or it may be studied as a science, but its perfection requires it to be considered as an art elucidated by science and guided by the latter as far as practical and economic conditions will permit.

As an art, the designing and constructing of steam engines has been by a purely tentative process—very long, very uncertain and very costly—brought to a high level: experience, with alternating success and failure, has been the blind guide under which the constructive instincts of a succession of engineers have blundered along until the successes of the present day have been achieved. But although science has contributed nothing to the growth of the steam

engine, it alone can explain its methods, point out the direction in which something more may be obtained, show the causes by which its operations are performed, demonstrate the limits to its progress, destroy false hopes, and give the ability to know when the utmost possible has been attained. It is retrospective and prospective; it not only illumines the path already passed over, like the stern-lights of an advancing vessel, but, like the bow-lights of the same vessel, it can show the way ahead with certainty and safety.

There is a very sufficient reason why science contributed nothing to the improvement, or rather to the proper understanding of the steam engine. The requisite science applicable for that purpose did not exist until quite recently. Not until the experiments of Regnault and the discovery and correlation of the facts of thermodynamics into a consistent system, could a true theory of the steam engine be formed; and until these researches were complete all advances had to be made tentatively by groping in the dark. There had, besides, to be made many and accurate experiments on engines of different types, dimensions and regimen, the results of which were to be confirmatory or subversive of the theory. Thus, the steam engine furnishes the best and surest foundation for thermodynamics up to the present hour; and it furnishes, also, the clearest and completest illustrations for that science. The proper methods of experimenting and of interpreting the results of the experiments had also to be devised. In physical investigations, even of the simplest kind, the deductions of science cannot be accepted with confidence until they are verified by experiment; and still less could such deductions be received without the fullest experimental evidence in so complicated a case as that of the steam engine. Without the results of Regnault's experiments on steam, and without the principles and data of thermodynamics, the performance of the steam engine would still remain the mystery it previously was.

The steam engine has been termed an elastic-pressure engine, and a heat engine, neither of which terms is philosophically correct, nor gives a clear apprehension of

the real facts of the case. The force which urges the piston of a steam engine is not an elastic force of the nature of the elasticity of a spring or of caoutchouc. It is, on the contrary, a concussive force acting by the impact of distinct molecules of steam, as a volley of bullets fired from a mitrailleuse acts against a resisting surface. The steam molecules are material bullets of infinitesimal dimensions moving with high velocities and endowed, consequently, with *vis viva* which must remain in them until imparted to other matter. Nor is the steam engine a heat engine in the popular sense of the word heat, for there is no such thing as heat as a distinct entity, and the term has meaning—apart from organic sensation—only when used as a synonym for molecular *vis viva*. The steam engine, considered in the concrete, is a mechanism for converting molecular *vis viva* into mass *vis viva*, the molecular *vis viva* being composed of the product of the number of steam molecules in use, the mass of each, and the square of their mean velocity. The mass *vis viva* is the useful or commercial load or resistance to be overcome, and is always a more or less small fraction of the molecular *vis viva*, the remaining portion of the latter being expended in the processes which the steam undergoes from leaving the boiler to entering the condenser, and imparted to the condensing water, or, if the engine be a non-condensing one, escaping unused with the exhaust steam into the atmosphere. The greater the fraction which the mass *vis viva* is of the molecular *vis viva*, in the case of the steam engine, the greater is the economy with which the mass *vis viva* is obtained or the commercial work done; and this fraction is affected so largely by the mechanism itself and by the material of its construction, apart from the manner in which the steam is used, that no theory of the steam engine can be complete which does not include these effects due purely to the mechanism and its matter.

By considering all the effects produced by steam in its passage through a steam engine as simply dynamical, resulting from a mechanical cause and identical with those produced by bodies in motion striking other bodies, a clear

and intelligible idea is obtained of the operations, which is impossible by considering them as the effects of heat or of elasticity. As particular cases of *vis viva* these effects are visible and tangible to the mind, because, when the masses are large enough, the effects are visible and tangible to the senses, and what is true in the one case is true in the other, the laws of mechanics as derived from the phenomena of sensible masses in motion being precisely the same as those of the insensible masses called molecules in motion; the magnitude of the mass does not affect the laws. Inferences can be drawn and results calculated *à priori* when the case is simply one of *vis viva*, but when the effects are referred to heat or to elasticity nothing definite is apprehended. The erroneous notion of the nature of heat which so long prevailed were due to a failure in perceiving these facts. Nevertheless, the terms "heat," "elasticity" and "pressure" are so thoroughly interwoven in the units of measure, in the formulæ, in the literature, and in the reasonings of engineering science, that they will, probably, never be eradicated. They are brief and useful, and when their true import is known there are no objections to their retention.

One of the most important facts discovered by the experiments of Regnault, is the increase in the latent heat of steam as its pressure becomes lower. If steam be expanded or lessened in pressure without doing external work, the difference of its temperature before and after expansion would tend to superheat it at the lower pressure, but as the latent heat increases with the decreased pressure, the tendency of this increase is to absorb heat, so that the condition of the steam after the free expansion—whether superheated or saturated—would be determined by the relative quantities of heat thus set free or absorbed. Now, the absorption of heat by the increase of the latent heat is greater than the heat liberated by the difference of temperature, so that steam expanding without doing external work would remain in the saturated state, a contrary result to the free expansion of an ideal gas, and, moreover, would undergo a liquefaction of a portion to furnish the heat

required to maintain the remainder in the state of steam. Saturated steam, therefore, will partially liquefy by expansion *per se*, and to an extent determined by the excess of the increase in its latent heat over the heat due to the difference of its temperatures before and after expansion. If, however, the expanding steam does external work, there will be transmuted into the work of expansion a portion of the heat of the steam, and the quantity of heat thus transmuted is much more than sufficient alone to keep the steam in the saturated state, consequently, the whole of the difference between the latent heats due to the pressures before and after expansion will have to be furnished by the liquefaction of a sufficient portion of the steam to liberate the heat required to maintain the rest of the steam in the state of steam. Expanding steam, therefore, when doing external work, undergoes a partial liquefaction additional to the liquefaction due to this work, and in proportion to the difference between its latent heats at its pressures before and after its expansion. This liquefaction may be called the liquefaction due to the expansion *per se*.

The latent heat of a pound weight of saturated steam is the measure of its *vis viva* in units of heat. The molecules of the steam must be endowed with that quantity of *vis viva* to remain in the form of steam. Now, as more *vis viva* or heat, (exclusive of the heat transmuted into the external work of expansion,) is required to keep the molecules of expanded steam in the state of steam under lower, than under higher pressures, the quantity of *vis viva* in the expanded steam will be insufficient to maintain the whole of it in the form of steam, and the excess must lose its *vis viva* and liquefy. This excess admits of calculation. There must liquefy such a fraction of the weight of the expanding steam as the difference between the latent heats of the steam before and after expansion is of the latent heat before expansion. This quantity of liquefaction takes place in all cases of expanding steam when the steam remains saturated during the expansion. The fraction in pounds of the weight of the expanding steam thus liquefied by what may be called its expansion *per se*—a liquefaction additional

to the liquefaction due to the transmutation of part of the heat of the expanding steam into the external work of the expansion—multiplied by the latent heat of the steam before expansion, gives the number of units of heat transmuted into the additional *vis viva* required. The quantity of heat thus transmuted depends obviously on the degree to which the steam is expanded, and the pressure from which it is expanded, but under the average conditions of practical steam engines, it will be found a very serious quantity exerting a marked influence on the economy with which the power is developed.

The following question must now be answered: In what state is the water of liquefaction due to the expansion of steam *per se* to be found, and how is this liquefaction distributed among the molecules of the steam?

Steam is composed of hydrogen and oxygen, and its simplest conceivable molecule would contain two atoms of the former and one atom of the latter; but the real steam molecule is doubtless a group of such simple molecules linked together in an unknown manner and acting as a unit. The molecule is acted on by a certain force, which maintains it at a determinate speed, its *vis viva* being represented by the product of its mass into the square of its speed. If, now, (say) one-half the mass be detached, the impelling force remaining as before, the remaining half mass will move with increased speed and will have a corresponding increase of *vis viva*. This is what takes place with steam when it expands; every steam molecule undergoing partial liquefaction; that is, liquefaction of one or more of the simple molecules composing it, in order that the remaining simple molecules of the steam molecule may receive the necessary increase of *vis viva* for maintaining them in the form of steam. Always, when saturated steam expands, with or without doing external work, this molecular liquefaction occurs, and in proportion to the measure of the expansion. The more the steam is expanded, the more of the simple molecules composing the original steam molecules will be liquefied. Expanded steam is thus wet steam, and wetter in proportion as it is more expanded. Further,

it is the only kind of wet steam. This water of liquefaction being in infinitesimal drops or masses, will long remain suspended mechanically in the remaining steam, rendering the latter opaque and giving it the appearance of haze, mist, fog or cloud. With sufficient time, however, these inconceivably small drops of water would precipitate by gravity upon the surfaces beneath them, but their descent through the resisting medium of the steam would be so exceedingly slow that in the case of the steam engine this precipitation never occurs for want of time, and the liquefied simple molecules are swept through the engine without sensible deposition. Unexpanded steam is always transparent; it is an invisible vapor; nor is its invisibility affected by mere mixture with it of additional water of the same temperature, as in the case of boilers priming or foaming. The primed or foamed over-water constitutes a distinct mass, side by side with the steam, but not intimately mingled with it, and separable almost instantly by gravity. The steam itself in this case is not wet.

Until the constitution of matter and the forces which produce the movements of its atoms are exactly known, the precise conditions of no physical problem can be given, but even with vague generalizations, confirmed by experiment, some approach can be made to a decision. Above all, in order to understand the action of any force, we must be able to form material conceptions of its operation, without which tangibility we cannot have any real grasp of the subject.

There remains a second cause of liquefaction of expanding steam in a steam engine, namely, the external or commercial work done by that steam, including overcoming the back pressure against the piston; this liquefaction is directly proportional to the heat transmuted into the work done by the expanding steam, counting that work down to the zero of pressure. In other words, the foregoing deals with the consumption of heat, or of *vis viva*, connected with the transference of heat or *vis viva* from some of the molecules of the expanding steam to the remainder in order to maintain the equilibrium of the latter after the expan-

sion, the action being wholly internal to the steam, and neither affecting nor being affected by the external work done by the expanding steam; but when steam expands against an external resistance it does external work, undergoing thereby a corresponding loss of heat, and suffering an equivalent liquefaction.

The steam molecules strike the piston with a *vis viva* represented by the product of their mass into the square of their mean velocity. The loaded piston being free to move, yields to the impact, and in moving takes up a portion of the *vis viva* of the striking molecules, which of course lose exactly that portion, having transferred it to the piston. As regards the steam in the cylinder previous to the commencement of its expansion, this loss of *vis viva* is instantly restored from the boiler (at the expense of the fuel), so that no liquefaction of steam takes place in the cylinder from this cause previous to its expansion, the loss of heat being transferred from the cylinder steam to the boiler steam, which continually receives fresh accessions of heat from the burning fuel. There is a real liquefaction of steam in the boiler corresponding to the heat equivalent of the work done in the cylinder previous to the expansion of the steam, but the water of this liquefaction is instantly revaporized in the boiler by the fuel. But when the steam commences to expand, after the closing of the cut-off valve of the cylinder, it is separated from the boiler steam, and can no longer receive accessions of *vis viva* or heat therefrom; consequently, all the heat transmuted into the external work of the expanding steam has then to be taken from that steam itself, which undergoes a resulting liquefaction corresponding to the heat or *vis viva* transmuted into this work. When expanding steam does external work, it not only partially liquefies correspondingly to that work, but that liquefaction is accompanied by the additional liquefaction due to the increase of the latent heat. The greater the expansion the greater the liquefaction from both causes. The temperature of expanding steam, when that steam remains in the saturated state, as it does when performing work, decreases with each increase of expan-

sion; and, when it falls to something less than 32°F., it changes into water; the liquefaction has become total, and that is the physical limit of the expansion of saturated steam.

The quantity of heat or molecular *vis viva* transmuted by expanding steam into the external work developed by the expansion can be calculated. Accepting 789¼ foot-pounds of work as the mechanical equivalent of one Fahrenheit unit of heat, the division of the number of foot-pounds of work done by the expanding steam, by 789¼, gives the number of Fahrenheit units transmuted into that work, and if this quotient be divided by the mean latent heat of the expanding steam, the quotient will give the number of pounds weight of steam liquefied to furnish this quantity of heat.

The number of foot-pounds of work done by the expanding steam must be obtained experimentally (by an indicator in the case of the steam engine), as the curve of the expanding pressures cannot possibly be calculated, even under abstract conditions, much less under the practical conditions of a steam engine.

From the moment the steam begins to expand there are simultaneously a continuous molecular liquefaction of a portion of it, and a continuous diminution of its temperature, both of which tend to lessen its pressure. There is, also, during the expansion portion of the stroke of the piston, a continuous evaporation of steam from the water of liquefaction due to the heat interaction of the metal of the cylinder with the steam, and this evaporation tends to continuously increase the pressure. Now, if the lessening of the pressure by the molecular liquefactions were exactly compensated by the increasing of the pressure by the steam of the revaporized water of liquefaction due to the interaction of the metal of the cylinder, the curve of the pressures of the expanding steam would exactly follow the Mariotte law. Again, the molecular liquefactions and the decrease of temperature are caused wholly by the expansion of the steam, and the interaction of the metal of the cylinder is likewise caused almost wholly by

the expansion of the steam, so that if all the water of liquefaction due to the interaction of the metal were revaporized during the expansion portion of the stroke of the piston, which, in general, is the fact, and if all the molecular liquefactions took place during the same portion of the stroke, the two should counterbalance each other, for they stand in the relation of cause and effect. But all the molecular liquefactions do not take place during the expansion portion of the stroke of the piston, some liquefaction takes place during the exhaust stroke, caused by the expansive expulsion of the steam from the cylinder after the opening of the exhaust port, and some liquefaction takes place due to the transportation of the steam from the boiler to the cylinder. In general, the steam evaporated from the water of liquefaction due to the heat interaction of the metal during the expansion portion of the stroke, exceeds by a very variable fraction (sometimes very small and sometimes quite large, according to the regimen of the steam), the molecular liquefactions during the same portion of the stroke, so that the pressures given on the indicator diagram by the expanding steam rise higher and higher above the pressures due to the Mariotte law, as the piston advances, until at the end of its stroke the difference is the greatest. When the steam is used without expansion in medium-sized and large cylinders, it experiences but very little liquefaction.

The liquefaction due to the transmutation of the heat of part of the expanding steam into the work of expansion, is effected upon every molecule of that steam, and the resulting water, in infinitesimal drops or flakes, continues suspended in the remaining steam, giving it the appearance of haze, mist, fog or cloud, the opacity being the greater as the work of expansion is greater, whereas non-expanded steam, though doing work, is perfectly transparent. This form of liquefaction of the steam is just the same as previously described for the similar liquefaction due to the increasing latent heat that accompanies expansion. But there is this difference that, in the case of the increasing latent heats, the liquefactions were caused by the transference of *vis viva*

from one portion of the steam molecules to another portion, while in the case of expansion doing work the liquefaction is caused by the transmutation of molecular *vis viva* into the mass *vis viva* represented by the load on the piston. But in both cases the final effect was the same, namely, the waters of these liquefactions were in the form of excessively comminuted spray as intimately mixed with the steam as its own molecules were intermingled. These extremely light particles of spray can not for want of time, and because of the resistance of the steam medium, precipitate by gravity upon the cylinder surfaces beneath, they, therefore, remain suspended in the steam and are swept out with it during the exhaust. Of course, the bulk of these waters of liquefaction was added to the bulk of the steam which thus appeared by that much greater than it really was. The expanded steam, as has been shown, is *wet* steam, and *wetter* the more expansively it is used.

The two liquefactions that have been described are inseparable from the use of saturated steam expansively.

Thus far there has only been considered the liquefactions of steam which take place in the cylinder of a steam engine using steam expansively, independently of any liquefaction that may be effected by the alternate heating and cooling of the metal of the cylinder during a double stroke of its piston, caused by the expansive use of the steam. This latter liquefaction must now be considered.

Taking first the case of an engine in which the steam is used without expansion, and, therefore, dry; and supposing the cylinder at the commencement of the stroke of its piston to have the temperature of the steam entering from the boiler, then, during the steam stroke of the piston, there will evidently be no liquefaction of steam. When the exhaust valve opens, the steam is expelled by its own expansion from the cylinder into the condenser, where it is annihilated. During this expansive expulsion of the exhaust steam it does, owing to its expansion, molecular work, and undergoes corresponding liquefaction. As the exhaust steam does no mass work during its passage into the condenser, because it is there annihilated, it will suffer only

the slight fall of temperature due to the molecular work of its expansion, and will therefore have but a trifling effect in cooling the metal of the cylinder. Hence, in the case of using steam without expansion, the interaction of the metal of the cylinder with the heat of the steam is very small, the temperature of the metal of the cylinder varying but little during a double stroke of its piston, from the temperature normal to the pressure of the entering steam. When the steam is used without expansion, the interaction of the metal of the cylinder with the heat of the steam is, therefore, very little during a double stroke of the piston.

Whatever temperature the metal of the cylinder loses during a double stroke of its piston, is restored to that metal by the steam entering from the boiler, which steam consequently undergoes a liquefaction corresponding to the quantity of heat thus transferred from it to the metal. The water of this liquefaction is uniformly deposited like a dew upon the inner surfaces of the cylinder and remains there to the end of the stroke of its piston, if the steam be used without expansion. When the exhaust valve opens and the pressure of the exhaust steam is lessened to nearly that of the space into which it is discharged, the deposited water of liquefaction is rapidly boiled off or revaporized under the lessened pressure, partly by its own contained heat, but principally by the heat of the metal on which it rests, taking from the latter an equivalent quantity of heat and reducing its temperature accordingly. The heat of vaporization of this water of liquefaction passes out of the cylinder with the exhaust steam and is lost.

The absolute dimensions of the cylinder are of importance in this relation. The larger those dimensions the less will be the liquefactions due to the heat interaction of the metal and steam, in proportion to weight of steam used from the boiler. For example, if all the dimensions of a cylinder be doubled, its surface will be increased four times, but its capacity will be increased eight times. In this case the influence of the surface on the liquefaction will be halved, relatively to weight of steam used from the boiler.

The loss of heat by the metal of the cylinder in the case

of using the steam without expansion, is then of two kinds: (1) That of the heat abstracted from the metal and carried out of the cylinder by the exhaust steam, due to the slight cooling of that steam by its molecular work during its expansion into the condenser: and (2), that of the heat of vaporization of the water of liquefaction caused by the above abstraction of heat from the metal, having to be restored by the entering steam, which suffers in consequence a corresponding liquefaction.

When, however, the steam is used expansively, doing external work, the liquefactions of the steam in the cylinder rapidly increase as the measure of expansion increases. After the closing of the cut-off valve, the temperature of the metal of the cylinder being supposed to be then equal to that of the steam entering from the boiler, the pressure and temperature of the steam decrease continuously to the end of the stroke of the piston, and, as a consequence, the expanding steam continuously abstracts heat from the metal of the cylinder from the commencement to the end of the expansion. During the entire expansion the steam is in the saturated state, notwithstanding the fact that its temperatures at lower pressures are less than at higher ones, because the heat transmuted into the work of the expansion is greater than the heat due to the differences of temperature. Were the opposite of this the case; that is, were the heat transmuted into the work of the expansion less than the heat due to the difference of temperature for the expansion, the expanding steam would become superheated, and there could be no liquefaction resulting from the expansion. Such, indeed, is the fact in the case of steam at exceedingly high pressures and correspondingly high temperatures. There is a pressure—far above what can ever be employed in practice—at which inversion of these relations takes place, the heat equivalent of the work of expansion being then less than the heat due to difference of temperature, and superheating instead of liquefaction would, under that condition, be the result of using the steam expansively.

Returning to the expansion of steam under practical conditions. As the pressures and, consequently, the tempera-

tures of the steam fall with the expansion, the steam becoming wetter and wetter, too, the further the expansion is carried, having its heat interacting power with the metal continuously increased in proportion to its increasing wetness, the metal of the cylinder is continuously cooled, keeping pace with the lessening temperatures of the expanded steam, until when the end of the expansion, or end of the stroke of the piston is reached, the temperature of the metal and that of the steam at the end of the stroke of the piston are equal, if not to the entire depth of the metal, at least to a considerable part of that depth. Now, when the piston is at the end of its stroke, the metal of the cylinder has been reduced from the temperature of the steam entering from the boiler, which it had at the closing of the cut-off valve or commencement of the expansion, to the temperature of that steam after its expansion was completed. The exhaust valve now opens, and if the steam has not been expanded to the condenser pressure, a further expansion then takes place to nearly that pressure, and the heat of the revaporization of the water of liquefaction present in the cylinder at the end of the stroke of its piston, under this lessened pressure of the condenser, being chiefly abstracted from the metal of the cylinder, reduces the temperature of that metal to nearly the temperature of the condenser. The whole of the heat required to raise the temperature of the metal from the temperature of the condenser pressure to that of the entering steam, must be restored from the heat in the latter, which, of course, suffers a corresponding liquefaction in furnishing it. The whole of the water of this liquefaction is present in the cylinder when the cut-off valve closes, and has the temperature of the steam from which it was derived. From the closing of the cut-off valve it commences to revaporize, and continues to boil off during the succeeding expansion portion of the stroke of the piston, and during the return stroke while the exhaust-valve is open, if any remains not vaporized at the end of the expansion part of the stroke, the whole disappearing in vapor from the cylinder by the time the exhaust stroke is completed. There is no water in the

cylinder on the exhaust side of the piston when the latter reaches the end of its stroke; were this not the case, there would be an accumulation of water in the cylinder that would soon stop the engine.

The water of liquefaction in the cylinder is vaporized under the continuously lessening pressures and temperatures of the expanding steam, partly by its contained heat, but principally by the heat of the metal, and the steam from the portion thus vaporized during the expansion part of the stroke is utilized in pushing the piston. This utilization, however, is vastly less than what would be obtained from the same quantity of heat employed to vaporize water in the boiler were the resulting steam used in the cylinder. Except for this steam from the revaporized water of liquefaction in the cylinder, the pressure of the expanding steam on the piston, as shown by the indicator, would be greatly less; in fact, a very considerable portion of the expansion pressures in the cylinder is composed of this steam of revaporization, and is not due to the expansion of the steam of the pressure in the cylinder at the closing of the cut-off valve.

The practical curve of the expanding steam, as given by the indicator, is so complicated by this steam of revaporization, the proportion of which to the steam evaporated in the boiler varies so greatly with dimensions and type of engines and with the regimen of the steam as to render the various formulæ for calculating the pressures of expansion mere rubbish. No formula, rational or empirical, can possibly be devised that will reproduce the practical pressures. The only information which can be obtained in this matter is from the indicator, and each case is a special problem requiring a distinct experimental solution.

The portion of the steam re-evaporated during the exhaust stroke of the piston, if there be any such, passes out of the cylinder not only without doing any useful work on the piston, but actually opposing its motion, thus increasing the prejudicial resistance of the condenser pressure. It also carries out of the cylinder the entire heat of its evaporation, none of which can be utilized.

A word of caution is necessary here as regards the pressure at the end of the stroke of the piston in a cylinder, when the expansion of the steam is carried considerably below the atmospheric pressure. Thus far, the assumption has tacitly been made that pure steam only is used in the engine; practically, however, there is a good deal of air mixed with it, derived not only from the atmospheric gases dissolved in the feed water, but also from the air pumped in by the feed pump, and also from the air leaked in through the various vacuum joints of the cylinder and its attachments. Now, this air appears upon the indicator diagram as steam pressure, and falsifies it to that extent. Moreover, the mixture of air with the steam diminishes to a certain extent the liquefaction of the latter by metallic contact, because it causes the pressure of the steam to be less than is due to its temperature. Further, all the pressure produced by the air present with the steam falsifies not only the steam pressures on the indicator diagram, but the power developed by the cylinder, because, as that air has to be pumped out by the engine, the power consumed in this pumping will about equal the power produced upon the piston by the air. By allowing a considerable inleakage of air to a cylinder, it can be made to appear to develop a much greater power than it really does, as computed from the diagram, and in experiments using steam very expansively, this error has frequently been inadvertently made, and to no small a degree. The temperature in the condenser rarely much exceeds 100° F., which corresponds to a saturated steam pressure of about one pound per square inch: now the mean pressure in condensers is about two pounds per square inch, being composed of steam and air in equal portions. And, still more, the mixture of air with the steam in the cylinder at the end of the stroke of the piston, causing the pressure there to be higher than is due to the steam, vitiates the calculation of the weight of steam present in the cylinder as such at the end of the stroke of the piston, making it appear larger than it is, and, consequently, making the liquefactions, as computed from the diagram, appear less than they really are.

The entire liquefaction of steam, due to the interaction of the metal of the cylinder takes place in the cylinder between the commencement of the stroke of its piston and the point of cutting off the steam, or closing of the cut-off valve. From that point to the end of the stroke of the piston; that is, during the expansion portion of the stroke of the piston, the expanding steam, with continuously lessening temperatures as well as pressures, is continuously abstracting heat from the metal of the cylinder and thereby cooling it, the temperature of the metal falling continuously from the temperature of the steam at the point of cutting off to that of the steam at the end of the expansion, or end of the stroke of the piston. After the exhaust valve opens, there is a still further expansion of the escaping steam accompanied with further lessening of the temperature of the metal of the cylinder. Now the whole of the steam liquefied to furnish the heat required to raise the metal of the cylinder from the temperature of the back-pressure steam to that of the entering steam, is liquefied in the cylinder between the opening of the steam admission valve and the closing of the cut-off valve. This is the liquefaction due alone to the interaction of the metal of the cylinder with the steam, but does not include the other causes of liquefaction of the steam.

If the metal of the cylinder remained constant at the temperature of the entering steam, there would be no liquefaction due to its interaction, but the liquefactions would remain the same that are due to other causes.

[*To be continued.*]

CORRESPONDENCE.

THE USE OF THE DIAMOND DRILL OF THE ANCIENT EGYPTIANS.

The Committee on Publications:

GENTLEMEN:—While preparing the lecture on "The Diamond Drill and its Work," which I had the honor to deliver, last February, before the FRANKLIN INSTITUTE, I wished to secure some authoritative confirmation of a published statement that the "diamond drill," or its equivalent, had been used by the ancient Egyptians. I, therefore, wrote the Hon. James G. Blaine, Secretary of State, asking his kind offices in the interest of science in securing from the Consul-General of the United States at Cairo, Egypt, answers to certain questions relative to the matter. These questions were very kindly forwarded by the Department of State, to the Hon. Eugene Schuyler, Consul-General of the United States at Cairo, whose reply did not reach me in time for incorporation in my lecture; and I now take great pleasure in fulfilling my promise by enclosing a copy of it to you, as it is a complete confirmation of the statements made by me relative to the use of "diamond drills," or similar tools, by the builders of the pyramids.

Yours truly,

W. F. DURFEE.

Birdsboro, Pa., July 26, 1890.

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[COPY NO. 46.]

Agency and Consulate-General of the United States.

CAIRO, EGYPT, March 1, 1890.

Hon. William F. Wharton, Assistant Secretary of State:

SIR:—In reply to your despatch No. 12, dated December 7, 1889, enclosing a letter from W. F. Durfee, of Birdsboro, Pa., on the use of diamond drills by the ancient Egyptians, I have the honor to say that, after consulting very many persons, I at last hit on the one man who has invented the theory—Mr. Flanders Petrie. I enclose a copy of a statement made by him on the subject. I have the honor to be, sir,

Your obedient servant,

EUGENE SCHUYLER.

—

[ENCLOSURE IN DESPATCH NO. 46.]

Statement of Mr. Flanders Petrie.

(1) The specimens of work which demonstrate the use of jewel points in sawing, drilling, etc., are drawn in my book, *Pyramids and Temples of Gizeh* (both editions); and the same plate is in the *Journal of the Anthropological Institute* for 1882 or '83, referred to in the chapter on "Pyramids and Temples," and in the *Journal*, but the account of mechanical methods in general is fuller in the *Journal*.

(2) There are no specimens in the Bulak Museum for the purpose of illustrating the subject; all the more able specimens are in my own possession, in England. But for a resident in Egypt, I would name the following examples that may be noticed:

(1) Base of tube-drill hole, cut too deep in roughing out the statue, between the feet of the diorite statue of Chephren (Kofra), in the Bulak Museum.

(2) Sides of two drill holes, showing on the inside of the sarcophagus at Gizeh; the marks are near the top, at the N. end of E. side, and on the W. end.

(3) Saw-cut too deep into the outside of that sarcophagus, on the N. end, near the top at N. E. edge.

(4) Saw-cut surface beneath sarcophagus in second pyramid, Gizeh.

(5) Drill hole, with core sticking in it, in granite lintel of chamber leading from the S. W. corner of the great hall of the granite temple of Gizeh; the fifth hole.

(6) I believe some small drill-holes are in the Hyksos head in black granite from Bubastir, in the Bulak Museum, the eye sockets having been cut out by drill-holes.

If casts are wanted, plaster-casts can easily be taken of Nos. 1, 2, 3, 4; and gutta-percha casts of Nos. 5 and 6.

NOTES AND COMMENTS.

CHEMISTRY.

LIQUID KINO.—By J. H. Maiden, Curator of the Technological Museum, Sydney. Proceedings of Royal Society of Victoria, 1890, p. 82.—*Angophora intermedia*, D. C., the narrow-leaved apple tree, is a tallish tree, which extends from Victoria to Queensland, as is the only species of the genus which is found in the southern colony. In the following respect it is perhaps unique among Australian trees. Frequently, when an incision is made into the bark, and more particularly when the knobby excrescences sometimes found on this tree, are cut, there exudes a watery liquid, which occasionally is almost as clear and colorless as water, and at other times of an orange-brown or reddish-brown color, and of the consistency of a thin extract, or even as thick as treacle.

This is doubtless the substance which was sent from New South Wales to the Paris Exhibition of 1867, labelled "apple-tree juice," with the statement that it is used as a varnish; but this is not correct, as the liquid is aqueous. It is used by fishermen for tanning their nets. Mr. Kirton informed Baron von Mueller that a single tree will yield as much as two gallons of liquid, which is generally called "liquid kino." This is a modest computation for the tree which yielded the Bangley Creek sample (*infra*)—yielded from eight to ten gallons. The quantity is in any case by no means small, and is dependent on a variety of circumstances.

Two samples of this "liquid kino" having recently been forwarded to

the Technological Museum, the author has had an opportunity of examining it.

(1) From Bangley Creek, Cambewarra, N. S. W., of a clear reddish-brown color, and in order to give precision to the tint, it is very like raw linseed oil, Strasburg turpentine, or dark balsam of copaiba, but redder than any of them. It has a specific gravity of 1·008 at 15° C., and an acidulous smell (owing to the presence of acetic acid), accompanied by an odor not so pleasant, and reminding one somewhat of spent tan liquors. It deposits a quantity of sediment of a buff color, consisting almost entirely of catechol.

It contains tannin, ·772 per cent.; "non-tannin," ·508 per cent. (Löwenthal's method). The water amounts to no less than 98·3 per cent. The catechol was not estimated in this sample.

(2) This was obtained from Cambewarra, but from a different locality. It is darker in color than the preceding sample, being of a rich ruby color. Like No. 1, it deposits a small quantity of sediment (catechol). This liquid kino had a specific gravity of 1·022 at 15° C., when received in April, 1888.

The following results were obtained in December to January, 1889: Tannic acid, 3·048 per cent. (of the liquid kino without evaporating); "non-tannin," 1·27 per cent. (a portion of liquid kino, kept in agitation so as to obtain a fair proportion of sediment, was added to water to make up the strength of one grain of liquid kino to the litre); water, 96·7 per cent. (after filtration from deposited catechol). The catechol and a little phlobaphene, filtered off, were found to be in the proportion of ·495 per cent. of the original liquid kino. Ether, agitated with the filtrate, took up ·15 per cent., of which one-third was estimated to be catechol and the remainder resin.

Mr. Kirton has recorded liquid kino from the Illawarra District of New South Wales, but since there appears to be no reason why it should be found in one colony more than another, it will doubtless also be obtainable in Victoria, most likely on application to fishermen. H. T.

EXPERIMENTAL CULTIVATION OF MYROBALANS IN SOUTH AUSTRALIA. Trade report in *Jour. of Soc. of Chemical Industry*, vol. viii, p. 226.—The *Adelaide Observer* for December 29, 1888, states that the South Australia, Forest Department intends to plant seeds of myrobalans of commerce, which have been received from India, with a view of ascertaining whether they can be cultivated in the colony. The plant is used in dyeing cloth and leather. H. T.

BOOK NOTICES.

SPON'S TABLES AND MEMORANDA FOR ENGINEERS. By J. T. Hurst. Tenth Edition. New York: E. & F. N. Spon, 12 Cortlandt Street. 1889.

This smallest of engineers' hand-books, being just one-seventy-sixth part in bulk of its great contemporary (D. K. Clark's *Manual*), was made by an Englishman for use in Britain, and must of necessity give English measures and data. Accordingly we find that the ordinary English cart is stated as holding forty-five cubic feet, or two and one-half tons of clay; whereas,

our cart-load of dirt equals a cubic yard by measure and one and one-half tons by weight. English bricklaying is said to be measured by the rod, a means of estimating unknown to our artisans; that kind of work is done here by the cubic yard or by the 1,000 bricks, and English bricks themselves differ greatly in size from ours, as, for instance, the smallest bricks tabulated are those called "London stocks," which are 8¼ x 4¼ x 2¼ inches; ours, according to Trautwine, measure 8¼ x 4 x 2 inches. As no roofing tiles are used here, this information is foreign news only.

The data relating to masonry, on page 9, state very nearly our practice; but the stones named on page 10 are not indigenous to our soil, except granite.

Page 11 gives exclusively English materials and practice, and on page 12 the denominations of slate are purely English, and no aid, therefore, to the American artisan. Carpenter work on page 14 compares favorably with what we do, but to be available, the quantities should be given in accordance with our board-measure rule; and "deal standards," on page 15, have no meaning with us. The term "scantlings," on page 16, does not exist in the nomenclature of our work, and no "hard-and-fast" rules can be applied here to roof construction. There is a lack of statement of the properties of timber with rule units of strength, by the aid of which one can, with any kind of timber, adapt the same to the circumstances of any case.

Lathing is not an exact science in England. We find the statement on page 22: "One bundle of laths contains (nominally) 500 feet, frequently 360 feet." What kind of feet is not stated, nor the lengths of the lath. Perhaps these discrepancies are due to the laths being made of "fir" wood. Ours are of a different material.

The sizes of bolts, together with their heads, nuts and washers, are convenient for reference, and are near an average. As these proportions vary in every locality, every engineer will make his own rule from the material employed.

They furnish healthy washers in England, "half the thickness of the head and have twice the area." John Bull believes in being sure. A valuable addition to these general data would be the strength of bolts, which is just what the out-door engineer, on the spur of demand, wants to know from his vest-pocket manual.

The sizes given for rivets in any seam are those in ordinary use. But it is said: "In riveted joints, sectional area of rivets should equal that of plate after deducting rivet holes," which is the usual English statement, and is believed to mean the driven rivet, not the commercial size of the rivet, and plates and rivets are to be of iron; these qualifications, however, are not stated. There is some reason, nevertheless, for the rule as formulated, because the shearing resistance of iron is less than its tensional resistance, and the rivet gains in area of section in the riveting process.

This little book states: "There is no fixed value for the B. W. gauge. The only standard gauge is Whitworth's, of which Mr. D. K. Clark says: "It is entering into general use." Since the use of fewest words in the treat-

ment of every subject fits best here, therefore be it said: *The best gauge is that which gives the diameter and thickness in inches and decimals.*

We can hardly expect that sheet-iron dimensions and the weight of nails, and the like, given in this literary dot, will correspond with American practice. Such data can have only local value.

The English gallon is given, of course, and the weight of English coals. Manilla ropes are not mentioned, while much is said of hempen ones.

In reference to railway curves, on page 70, it may be said, how much better to employ the system, which gives the angle at the centre, or the angle between the two chords for a 100-foot chord, because there are no fractions to remember nor calculations to make, which certainly aid field practice. The centre, as a rule, is inaccessible, and the radius direct cannot be applied.

In a note to the condensed rules of mensuration, it is stated: "The prismoidal formula applies to earthworks, casks and truncated cones." It should have said that it will solve the solidity of every known regularly formed body, and for such a book as this a rule so general may be consistently inserted (in lieu of the host of them for solids, found in the larger books), with one worked-out example.

Under the head of "U. S. of America," the liquid gallon, which is most used in engineering calculations, is not given except by inference, and it should have been stated that the metric system of measures is not generally known or used.

While we have noted less than a score of extracts from the booklet, its 135 pages teem with engineering data invariably of value, having universal use.

We cannot say this volume adds much avoirdupois to the library shelf, but the adage, "precious goods come in small packages," is proven in this example, and, therefore, it should certainly find a place in the vest pocket of every engineer. J. H. C.

TREATISE ON LINEAR DIFFERENTIAL EQUATIONS. By Thomas Craig, Ph.D., Associate Professor in the Johns Hopkins University, Associate Editor of the *American Journal of Mathematics*. Vol. I: Equations with Uniform Coëfficients. New York: John Wiley & Sons. 1889.

Starting with the investigations of Fuchs, twenty-five years ago, the theory of linear differential equations has undergone rapid development, until now it has an extensive literature in the various periodicals. Prof. Craig has laid himself the task of collecting and presenting at one view this mass of material, thus making it available to a large number of students, to whom otherwise it would remain in great part inaccessible. The result is undoubtedly a treatise of great value, indispensable to the library of students in this department of mathematics.

Much of the matter is given nearly or quite in the form in which it appeared in the original memoirs. Notably is this the case in Chapter VII, which is a translation of Goursat's valuable thesis upon the linear differential equation that admits the hypergeometric series as an integral. In this chapter, the results of Gauss and Kummer are reviewed and the theory extended.

Similarly, Chapter IV is based upon Frobenius' paper, "Ueber die Integration der linearen Differentialgleichungen durch Reihen."

In Chapter I, the author reviews rapidly the general properties of linear differential equations; and, in Chapter II, he takes up equations having constant coëfficients, giving methods of Cauchy, Jordan and Méray.

Chapter III is devoted to a preliminary treatment of equations with singly and doubly periodic coëfficients. Some of the methods and results of Hamburger, Floquet and Jordan are given. The theory of groups is here introduced. It is further developed together with that of function-groups (the "faisceau" of Jordan), and of substitutions in Chapter XI. An application of the same theory is made in Chapter VIII to irreducible equations.

The theory of linear differential equations, all of whose integrals are regular, is continued in Chapter V; and in Chapter IX is discussed that of equations some of whose integrals are regular. Chapter VI is devoted to equations of the second order, having three critical points.

The subject of Chapter X is the decomposition of linear differential equations into symbolic prime factors. Some interesting analogies appear here between these equations and ordinary algebraic equations.

In Chapter XII, we find treated very briefly the case of equations whose integrals are rational, together with an allied class (Halphin's equations). The more general theory of equations whose integrals are algebraic is reserved for the subsequent volume.

Chapter XIII contains some account of the theory of transformation of a linear differential equation, particularly the reduction to Forsyth's canonical form. This involves something of the theory of invariants, the full discussion of which, together with that of equations with uniform doubly periodic coëfficients (the subject of Chapter XIV) is reserved for Vol. II. Chapter XIII contains, also, some account of Lagrange's associate equations.

Throughout the book the methods of the theory of functions are employed exclusively. The student will find, therefore, that a knowledge of these methods, as well as of the elementary theory of differential equations, is essential to success in reading the book.

In conclusion, we cannot refrain from adding a note of gratification at the issue of such a volume from an American press. It is one of the indications, which are becoming more common around us day by day, of the wide diffusion on this side of the Atlantic of a taste for advanced work in these higher fields of scientific research. C.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE

[*Stated Meeting held at the* INSTITUTE, *Tuesday, September 16, 1890.*]

HALL OF THE FRANKLIN INSTITUTE.
PHILADELPHIA, September 16, 1890.

Mr. T. C. Palmer, President, in the Chair.

Members present: Prof. E. F. Smith, Mr. Reuben Haines, Dr. D. K. Tuttle, Prof. N. Wiley Thomas, Mr. A. A. Moore, Mr. Lee K. Frankel, Dr. Wm. H. Wahl, Mr. Fred. E. Ives, Prof. R. L. Chase, Mr. A. T. Eastwick, Mr. G. L. Norris and four visitors.

Dr. Tuttle proposed the name of Cabell Whitehead, of the Mint Bureau, of Washington, as an associate member of the section; the name was referred to the Committee on Admissions.

Dr. Wahl presented the paper by Dr. Masser, of Los Angeles, Cal., on "The Curve of the Elements," which was to have been read by Dr. Persifor Frazer. It was read by title, and on motion it was decided to refer the article to a special committee for publication. The President named Dr. Wahl, Dr. Hall and Prof. Smith as members of this committee.

Mr. Reuben Haines then read a thoroughly-prepared paper on "The Use of Galvanized Iron in the Conveyance of Drinking Water." Some interesting results of the analysis of water conveyed in galvanized pipes were presented, and also a careful review of the most important literature on the subject. The paper was referred for publication in the JOURNAL.

An interesting discussion followed in regard to the immunity enjoyed by workmen engaged regularly in handling poisonous metals and their compounds. Dr. Wahl instanced, as a remarkable example of this, the continual inhalation by the workmen in the galvanizing works of zinc chloride vapors, produced by throwing ammonium chloride upon the surface of the molten zinc in the operation of galvanizing iron.

Dr. Tuttle called attention to the carelessness in regard to health shown by workmen in white lead works. Remarks were also made by the President and by Mr. Reuben Haines.

Adjourned.

WM. C. DAY, *Secretary.*

LECTURES FOR THE SEASON 1890-'91.

The following list embraces the Lectures arranged for the season 1890-91.

1890.

Nov. 10.—Prof. PERSIFOR FRAZER, D.Sc. Subject, *Some Helps and Hinderances to the Progress of Theoretical Chemistry.*

14.—Mr. C. J. HEXAMER. Subject, *From the Baltic to the Volga.* (Illustrated.)

17.—Dr. H. HENSOLDT, Columbia College, New York. Subject, *Some Methods and Examples of Mineralogical Research.*

21.—Prof. EDWARD D. COPE. Subject, *The Zoölogical Characters of Man.*

24.—Dr. BRUNO TERNE. Subject, *Ammonia: its Sources and Technical Uses.*

28.—Commander F. M. BARBER, U.S.N. Subject, *High Explosives in Warfare.*

Dec. 1.—Prof. G. G. GROFF, M.D., Bucknell Univ., Lewisburg, Pa. Subject, *The Organization of Sanitary Work in Cases of National Disaster.*

5.—Dr. L. WEBSTER FOX. (Subject to be announced.)

8.—Capt. F. A MAHAN, Corps of Engineers, U.S.A. Subject, *Philadelphia as a Seaport.*

12.—Mr. J. C. TRAUTWINE, C.E. Subject, *Engineering Notes from Europe.*

15.—Prof. WM. D. MARKS. Subject, *Two-and-a-half Miles a Minute.*

19.—Mr. FRED. E. IVES. Subject, *Photography in the Colors of Nature.* (Illustrated.)

29.—Dr. A. Victoria SCOTT. A Christmas lecture for the Children.—*A Trip to Alaska.* (With a series of fine views.)

1891.

Jan. 5.—Mr. JOHN CARBUTT. Subject, *Some New Applications of Photography.*

9.—Dr. LOUIS BELL, Editor *Electrical World*, New York. Subject, *Electricity as the Rival of Steam.*

12.—Prof. J. W. RICHARDS, Lehigh University, Bethlehem, Penna. Subject, *The Aluminium Problem.*

Jan. 16.—Mr. C. J. HEXAMER. Subject, *Light in the Dark Continent.* (Illustrated.)

19.—Prof. F. W. CLARKE, Washington, D.C. Subject, *The Chemical Elements.*

23.—Mr. C. J. H. WOODBURY, C.E., M.E., Boston. Subject, *Conflagrations in Cities.*

26.—Prof. ELIHU THOMSON, Lynn, Mass. Subject, *Induction of Electric Currents and Induction Coils.*

30.—Mr. F. LYNWOOD GARRISON. Subject, *New Alloys in their Engineering Applications.*

Feb. 2.—Dr. E. C. KIRK. Subject, *The Hygiene of the Mouth.*

6.—Mr. PARK BENJAMIN, New York. Subject, *Science in Modern Naval Warfare.*

9.—Mr. JOHN BIRKINBINE, Engineer. Subject, *The Development of the Pig Iron Manufacture in the United States.*

13.—Mr. GEORGE F. KUNZ, New York. Subject, *Occurrence of Gems and Precious Stones in North America.*

16.—Mr. OBERLIN SMITH, Bridgeton, N. J. Subject, *Possibilities of Applied Science.*

20.—Mr. HORACE L. PIPER, Assistant-General Superintendent, U. S. Life-Saving Service, Washington, D. C. Subject, *The Life-Saving Service.*

23.—Dr. H. A. SLOCUM. Subject, *Diseases and Remedies in the Light of Modern Medicine.*

27.—Mr. WALTER C. KERR, New York. Subject, *The Steam Loop for Returning Water of Condensation to Boilers.*

THE DRAWING SCHOOL.

WILLIAM H. THORNE, Director.

The Winter Term begins September 23, 1890, and ends January 8, 1891.

The Spring Term begins January 13, 1891, and ends April 23, 1891, when the closing exercises will be held in the Hall.

Each term comprises fifteen weeks, Tuesday and Thursday evenings.

Thorough instruction, based upon the most modern and approved practice, will be given in mechanical, architectural and free-hand drawing.

Admission to the Lectures of the INSTITUTE is free to the scholars on Monday and Friday evenings.

Tuition fee—$5 per term of fifteen weeks.

Tickets may be had at the Hall of the INSTITUTE, 15 South Seventh Street.

H. L. HEYL, *Actuary*.

THE SCHOOL IS DIVIDED INTO THE FOLLOWING CLASSES:

Junior Class, in which drawing tools and their proper manipulation, lines, surfaces and single solids with plane surfaces, are treated.

Intermediate Class, in which solids with curved surfaces, the intersections of solids, and the development of their surfaces, are treated.

All students are advised to go through these classes, in order thoroughly to understand the principles of draughting, before entering the Senior or the Architectural Class.

Senior Class, in which the methods, technicalities and style of draughting and designing engineering work, are treated.

Architectural Class, in which designs, plans, elevations and details of buildings, and of interior and ornamental work, are treated.

Free-hand Class, in which free-hand drawing, with pencil and crayon from the flat and from casts, designing and oil-painting, are treated.

The class-rooms open at 7 P. M.

Instruction commences at 7.15 and ends at 9.15.

The full course comprises four terms, at the end of which certificates are awarded to those students who have shown sufficient attention, industry and progress.

In order that more efficient and rapid progress may be made, the Director has prepared text-books on mechanical drawing, with plates, which can be purchased at the class-rooms, together with all necessary tools and materials.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, September 17, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, September 17, 1890.

JOS. M. WILSON, President, in the Chair.

Present, 122 members and twenty visitors.

Additions to membership since last report, fourteen.

The President gave an account of his impressions of the Edinburgh Exhibition, which he had visited with the view to study and observation.

The following gentlemen were unanimously elected as honorary members of the INSTITUTE, having been recommended for such election by the Board of Managers:

Prof. E. MASCART, membre de l'Institute; Professor of the College of France, and Director of the Central Meteorological Bureau.

Mr. THEODORE TURRETTINI, Engineer, Geneva; Lt.-Col. Artillery, President of the City of Geneva; Director of the Works for the Utilization of the Motive-Power of the Rhone at Geneva, etc.; and

Prof. WM. CAWTHORNE UNWIN, F.R.S.; M.Inst.C.E.; Professor of Engineering at the Central Institution of the City and Guilds of London.

The Secretary reported that at the instance of the Committee on Science and the Arts, and with the cordial approbation of the Board of Managers, Mr. EDWARD LONGSTRETH, Vice-President of the INSTITUTE, had generously presented to the INSTITUTE the sum of one thousand dollars for the endowment of a medal of silver, to be designated as the "EDWARD LONGSTRETH MEDAL OF MERIT." The Secretary offered for inspection a specimen of this medal, whereupon Mr. SHAW offered the following resolutions, which were numerously seconded, and on being put to vote were unanimously adopted:

"*Resolved*, That the INSTITUTE hereby confirms the action of the Board of Managers in accepting the gift of foundation of the 'EDWARD LONGSTRETH MEDAL OF MERIT,' and in expressing its grateful acknowledgments for the gift.

"*Resolved*, That the grant of the EDWARD LONGSTRETH MEDAL—in accordance with the wishes of the donor—be entrusted to the Committee on Science and the Arts, subject to such conditions as the said committee, with the approval of the INSTITUTE, may impose."

Mr. ROBERT GRIMSHAW, M.E., of New York, read a paper on "Typewriting Machines." Discussed by Messrs. WIEGAND, LOCKWOOD and the author. (Referred for publication.)

Mr. W. N. JENNINGS exhibited and described a series of photographs of views, taken during a recent trip to the Pacific Coast.

Mr. G. M. ELDRIDGE called attention to a lot of samples of fabrics of

silk and other materials, woven on a knitting machine having bearded needles operated by cam motion. The machine is the invention of Mr. SAMUEL HOUGH, Jr.

The Secretary presented his monthly report, which embraced the following items of general interest, viz: An account of the construction of the railway tunnel under the St. Clair River, connecting Canada with the United States; an account of the progress on the work of the Nicaragua Canal; an account (with illustration) of the system of heating railway cars by steam, adopted, and about to be put in service by, the Pennsylvania Railroad Company. This description was prepared by Mr. THEO. N. ELY, General Superintendent of Motive-Power, and is referred for publication.

Mr. WM. E. LOCKWOOD called attention to the fact that a Committee of the Board of Trade was shortly to make an inspection of the plant for the purification of the Delaware River water by Anderson's process, that has been erected at Lardner's Point, by Mr. EASTON DEVONSHIRE; and expressed the hope that the sub-committee of the Science and Arts Committee of the INSTITUTE could co-operate with the first-named body.

He also placed on the Secretary's desk, and requested to be read, the following memorial to the National House of Representatives:

To the Honorable, the House of Representatives of the United States in Congress assembled:

This memorial of the Philadelphia Board of Trade respectfully represents—

That the National Museum, at Washington, D. C., with its valuable collection of specimens, affords educational advantages of incalculable value to the Nation;

That the government should make every effort to foster and encourage the further accumulation of such material as will mark historically the growth and progress of our country.

That ample provision should be made for the care, exhibition and safe-keeping of these accumulated treasures; therefore,

Your memorialist, the Philadelphia Board of Trade, earnestly petitions your honorable body to pass Senate Bill No. 2740, entitled "A Bill to provide for the erection of an additional fire-proof building for the National Museum."

And your memorialist will ever pray, etc., etc.

Mr. LOCKWOOD inquired if it would be in order for him to offer a similar memorial for adoption at this meeting.

The President stated that while the INSTITUTE, undoubtedly, warmly sympathized with the sentiments expressed in the memorial of the Board of Trade, and fully approved of its object—he deemed it inexpedient to depart from the uniform custom of the INSTITUTE in such matters.

Mr. ELDRIDGE referred to the fact that Mr. GRIMSHAW had some views to offer relative to the formation of a New York section of the INSTITUTE, whereupon Mr. GRIMSHAW was requested to favor the meeting with a statement of his views. At the conclusion of his remarks, Mr. GRIMSHAW was requested to address a communication on the subject to the Board of Managers.

Adjourned.

WM. H. WAHL, *Secretary.*

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE.

Alabama Agricultural Experiment Station. Bulletin 16 and 17. From the Station.

Albany Medical College:

Catalogue. 1889–90.

Proceedings of the Seventeenth Annual Meeting of the Association of the Alumni. From Willis G. Tucker, M.D.

Albany Steam Trap Company. Descriptive Circular. From the Company.

American Academy of Arts and Sciences. Proceedings. Vol. 16. From the Academy.

American Annual of Photography and Photographic Times Almanac. 1887 to 1889. From Frederic E. Ives.

American Association for the Advancement of Science. Proceedings. Vol. 38. From the Association.

American Chemical Society. Bulletin, First General Meeting. From the Society.

American Ephemeris and Nautical Almanac. Astronomical Papers. Vol. 2. Part 5. From the Nautical Almanac Office.

American Ephemeris and Nautical Almanac. Astronomical Papers. Vol. 4. From Nautical Almanac Office.

American Institute. Circulars of Fifty-ninth Exposition. From the Institute.

American Institute of Mining Engineers. Nine pamphlets subject to revision. From the Institute.

American Institute of Mining Engineers:

Courtis. Gold Quartz.

Egleston. The Treatment of Fine Gold in the Sands of Snake River, Idaho.

European. Trip of the Joint Party of Engineers in 1889.

Richards and Woodward. The Velocity of Bodies of Different Specific Gravity Falling in Water.

McDowell. Stripping Ore Deposits.

Dewey. The Lewis and Bartlett Bag-Process of Collecting Lead Fumes at the Lone Elm Works, Joplin, Mo.

Chance. Geology of the Choctaw Coal Field.

Jones. Phosphorus in Pig Iron, Steel and Iron Ore.

Hunt. Railway Splice-Bars and Specifications for their Manufacture.

Catalogue. List of Members.

Yardley. Specifications for Cast-Iron Coated Water Pipe.

Coxe. Biographical Notice of Franklin B. Gowen.

Raymond. Biographical Notice of William R. Jones.

Adams. List of Commercial Phosphates. From the Institute.

American Iron and Steel Association. Tariff Tracts. Nos. 1 to 5. From the Association.

American Public Health Association. Lomb Prize Essay. Practical Sanitary and Economic Cooking. From the Association.

American Railroad Journal. Vols. 38 to 43. From the American Iron and Steel Association.

American Water Works Association. Report of Proceedings. Tenth Annual Meeting. From the Association.

Annales des Ponts et Chaussées. Personnel. 1890. From the Publisher.

Art Club of Philadelphia:
Fairmount Park Art Association and its Work.
Pioneer in Industrial Art Education. From the Club.

Association pour Prevenir les Accidents de Fabriques. Compte-rendu du Vingt-deuxième Exercice. 1889. From the Association.

Board of Health, Keokuk, Ia. Fourth Annual Report. From the Physician.

Board of Public Works, Milwaukee. Annual Report for 1889. From the Board.

Botanic Garden, Adelaide. Report on the Progress and Condition during the Year 1889. From the Director.

British Association for the Advancement of Science. Report for 1889. From the Association.

Buffalo Historical Society. Twenty-eighth Annual Report. From the Society.

British Journal Photographic Almanac. 1880 to 1882, 1884 to 1887, 1889 From Frederic E. Ives.

British Patent Office. Specifications and Drawings. Vols. 57–80 of 1888. Eight parcels loose specifications of 1889. From the Office.

Canada. Customs Department:
Customs Tariff. 1890.
Customs Tariff. 1886–87.
Consolidated Customs Act. 1886. From the Department.

Childs, George W. Recollections of General Grant. From the Author.

Christensen, C. C. Graphical Diagram for Approximate Calculations. From the Author.

Codman, J. E. Dimensions of Pipe Flanges. From the Author.

Colliery Guardian. Vols. 12 to 14, 17, 19 to 21, 23 to 25, 27 to 30. From American Iron and Steel Association.

Congressional Record. Vol. 11. 1881. From the Department of the Interior.

Connecticut Agricultural Experiment Station. Bulletin No. 103. From the Station.

Electrical Bureau, Philadelphia. Annual Report for 1889. From the Chief.

Engine, Boiler and Employers' Liability Insurance Company. Chief Engineer's Report for 1889. From the Company.

Engineering Association of New South Wales. Minutes of Proceedings. Vol. 3. From the Association.

Engineers' Society of Western Pennsylvania. Meeting of May 25, 1890. From the Society.

Engineers' Society of Western Pennsylvania. Proceedings of Meeting June 17, 1890. From the Society.

Engineer. Vols. 20 to 35.
Engineering. Vols. 2 to 12. } From American Iron and Steel Association.

Fairmount Park Art Association. Seventeenth Report. From the Association.

Frazer, Persifor. Persistence of Plant and Animal Life under Changing Conditions of Environment. From the Author.

Frazer, Persifor. The Philadelphia Meeting of the International Congress of Geologists. From the Author.

Geldern, Otto von. Notes on the Dry-dock and Coffer-dam at the Navy Yard, Mare Island, Cal. From the Author.

Geological Survey of India. Records. Vol. 23. Part 2. From the Director.

Geological Survey of New Jersey. Annual Report of the State Geologist for 1889. From the Assistant in Charge.

Germanischer Lloyd. Internationales Register. Dritter Nachtrag. From L. Westergaard & Co.

Goppelsroeder, F. Ueber Feuerbestattung. From the Author.

Government of Bengal. Memorandum on the Snowfall. From the Government Reporter.

Hebrew Technical Institute. Second Annual Report. From the Director of Instruction.

Huyett & Smith Manufacturing Company. Sectional Catalogue of Heating and Ventilating Apparatus. From the Company.

Illinois Society of Engineers and Surveyors. Report of the Fifth Annual Meeting. From the Society.

Institution of Civil Engineers. Minutes of Proceedings. Vols. 100 and 101. From the Institution.

Internal Affairs, Pennsylvania. Annual Report. 1889. Parts 1 and 2. From the Secretary.

Iron. Vol. 4.

Iron and Coal Trades Review. Vol. 4 to 11.

Iron Trade Circular. 1865 to 1871, 1873 to 1875.

Jagenberg, F. Ueber thierische Leimung für endloses Papier, From H. C. Baird & Co.

Johnstown Flood Relief Commission (2 copies). Report of the Secretary. From the Secretary.

Journal of Commerce. Vol. 26. From American Iron and Steel Association.

Kansas State Board of Agriculture. Report for the Months of June and July. 1890. From the Board.

Kansas State Board of Health. Fifth Annual Report. From the Board.

Königliche Technische Hochschule. Programm für das Studienjahr 1890–91. From the Director.

K. K. Geologische Reichsanstalt. Abhandlungen. Band 4. Heft 2. From the Institution.

Lawes, John Bennet. Memoranda of the Origin and Results of the Field and other Experiments conducted on the Farm and in the Laboratory. From the Author.

Maiden, J. H. Wattles and Wattlebarks. From the Author.

Manchester Association of Engineers. Thirty-fourth Annual Report of the Council. Comparative Merits of Main Driving by Spur or Bevel Gearing, Belts or Ropes. From the Association.

Manchester Steam Users' Association. Annual Report for 1889. From the Association.

Marks, A. A. From the Stump to the Limb. From S. H. Needles.

Massachusetts State Agricultural Experiment Station. Analyses of Commercial Fertilizers. August, 1890. From the Station.

Massachusetts Bureau of Statistics of Labor. Annual Report for 1889. Statistics of Manufactures, 1889. From the Bureau.

Massachusetts Manual for the Use of Boards of Health. From State Board of Health.

Massachusetts State Agricultural Experiment Station. Bulletin No. 37. From the Station.

Mercantile Library Association, New York. Sixty-ninth Annual Report. From the Association.

Mercantile Library, Philadelphia. Bulletin No. 31. From the Librarian.

Meteorological Council, London. Official Publications. No. 83. From the Council.

Meteorological Department, India:
Report on the Administration in 1888-89.
Report on the Meteorology of India in 1888.
Cyclone Memoirs. Part 2.
Hand-book of Cyclonic Storms in the Bay of Bengal.
From the Department.

Meteorological Office, London. Weekly Weather Report. January to May, 1890. From the Office.

Michigan State Board of Health. Abstract of Proceedings. April 15, 1890. From the Board.

Mining Journal. Vols. 35 to 44. From American Iron and Steel Association.

Ministère de l'Instruction Publique. Annuaire des Bibliothèques et des Archives. 1890. From the Minister.

Mobile Board of Health. Annual Report, 1889. From the Board.

Müller, J. Principles of Physics and Meteorology. From Spencer Fullerton.

Musée, Teyler. Archives Série II, Vol. III, IV^e^ partie. Catalogue de la Bibliothèque. II^e^ volume. I^e^ to III^e^ livraison. From the Librarian.

Nathan Manufacturing Company. Catalogue. From the Company.

National Electric Light Association. Bulletin. No. 6. From the Association.

National Executive Silver Committee. First Report. From the Committee.

New Bedford Board of Health. Eleventh Annual Report. From the Board.

Newberry Library. Proceedings of the Trustees, 1889. From the Trustees.

New Brunswick, N. J. Seventeenth Annual Report of the Water Commissioners. From the Superintendent.

New England Steam Cooperage Company. Catalogue. From the Company.

New Jersey Agricultural College Experiment Station. Nos. 69–71. From the Director.

New Jersey Geological Survey. Final Report. Vol. 2. Part 1. From the Survey.

New Jersey Historical Society. Proceedings. Vol. 10, No. 5. Vol. 11, No. 1. From the Society.

New Jersey State Agricultural Experiment Station. Tenth Annual Report. Bulletin No. 68. From the Station.

Newman, Robert. Electrolysis in the Treatment of Stricture of the Rectum. From the Author.

New York Board of Railroad Commissioners. Report for 1889. From the Board.

New York State Library. Seventy-second Annual Report of the Regents. From the Director of Library.

New York State Pharmaceutical Association. Proceedings of the Twelfth Annual Meeting. From the Association.

New Zealand Institute. Transactions and Proceedings. Vol. 22. From the Director.

Norfolk & Western Railroad Company. Reference Book. From the Company.

North Carolina Agricultural Experiment Station. Annual Report for 1888. Bulletin No. 72. From the Station.

Oesterreichischer Ingenieur- und Architekten-Verein. Verzeichniss der Mitglieder. From the Society.

Ohio Agricultural Experiment Station. Bulletin, Nos. 3, 4 and 5. From the Station.

Osservatorio Astronomico della Regia Università di Torino. Publicazioni 1889. From the Observatory.

Ohio Mechanics' Institute. Thirty-ninth to Sixty-first Annual Reports. From the Institute.

Ohio Mechanics' Institute. Sixty-Second Annual Report. From John J. Weaver.

Oneida Historical Society. Address on Judge William Cooper. From the Secretary.

Packard, A. L. Guide to the Study of Insects. From Reuben Haines.

Famphlets:

Announcements of FRANKLIN INSTITUTE.
Catalogue of Exhibition.
Discourse, Academy of Natural Sciences.
List of Members. From Rev. George A. Latimer.

Paris Exposition. Eighteen Pamphlets. From Carl Hering.

Path, The. October and November, 1888. January and March, 1890. From Spencer Fullerton.

Peabody Institute. Twenty-third Annual Report. From the Institute.

Pelton Water-Wheel Company. Descriptive Pamphlet.
From the Company.

Pennsylvania:
Auditor-General. Report on Banks. 1889.
Agriculture of Pennsylvania. 1889.
Compendium of Laws relating to Public Health and Safety.
Fish Commissioners' Report. 1887–88.
Game and Fish Laws. 1889.
Geological Survey. Atlas A. A.
Industrial Education.
School Report. 1872.
State Librarian. 1888–89.
State Treasurer. 1889.
Smull's Hand-Book. 1890. From the Librarian of the Senate.

Pennsylvania Academy of the Fine Arts. Circular of the Committee on Instruction. From the Academy.

Pennsylvania Board of Agriculture. Forty-first and Forty-second Quarterly Reports. From the Board.

Pennsylvania Hospital. Annual Report of the Board of Managers for 1889. From the Board.

Pennsylvania Museum and School of Industrial Art. Circular of the Committee on Instruction. 1890–91. From the Secretary.

Pennsylvania Museum and School of Industrial Art. Fourteenth Annual Report. From the Secretary.

Pennsylvania State College. Catalogue. 1889–90. From the College.

Pennsylvania State Librarian. Report 1888–89. From the State Librarian.

Periodicals relating to Electricity, etc. Two hundred and forty-nine numbers. From David Brooks.

Petersen & Co. Catalogue of Desks and Office Furniture.
From the Company.

Philadelphia Board of Public Education. Seventieth and Seventy-first Annual Reports. From the Board.

Philadelphia Bureau of Water. Annual Report, 1887 and 1888.
From the Chief Engineer.

Philadelphia Map. 1775. From Carl Hering.

Pratt Institute, Brooklyn. Catalogue 1890–91. From the Institute.

Prouteaux, A. Papier et carton. H. C. Baird & Co.

Prudden, T. M. On Bacteria in Ice. From the Author.

Public Water Board of Lynn. Eighteenth Annual Report.
From the Board.

Pulleys, Hinges, Knockers, Latches, etc. Book of Illustrations.
From J. D. Sergeant.

Ritchie & Sons. Catalogue of Electrical Test Instruments.
From E. S. Ritchie & Sons.

Rose Polytechnic Institute. Eighth Annual Catalogue. From the Librarian.

Royal Cornwall Polytechnic Society. Fifty-seventh Annual Report.
From the Society.

Royal Irish Academy:
Cunningham Memoirs. No. 5.
Irish Manuscript Series. Vol. 2. Part 1.
Proceedings. Third Series. Vol. 1. Parts 2 and 3.
Transactions. Vol. 29. Parts 12 and 13. From the Academy.

Sang, Edward. Exhibition of Curves Produced by the Vibration of Straight Wires. From the Author.

School of Mines, Quarterly. Contents and Index to Vols. 1 to 10. From the Editors.

Scientific American. Five copies. From Spencer Fullerton.

Scientific American Reference Book. From Spencer Fullerton.

Scientific American. Vol. 12. From American Iron and Steel Association.

Seismological Society of Japan. Transactions. Vol. 13. Part 2. From the Society.

Sidney School Furniture Company. Catalogue. From the Company.

Smithsonian Institution. Annual Report of the Board of Regents. 1886, parts 1 and 2. 1887, parts 1 and 2. From the Institution.

Smithsonian Institution. Contributions to Knowledge. Vol. 26. From the Institution.

Smithsonian Institution. Index to the Literature of Thermodynamics. From the Institution.

Sociedad Cientifica "Antonio Alzate" Memorias Tomo 3. From the Society.

Société Vaudoise des Sciences Naturelles. Bulletin No. 100. From the Society.

Society of Sons of the Revolution. Constitution, By-Laws, Membership. From the Secretary.

Springfield (Ohio) Water Works. Tenth Annual Report. From the Superintendent.

Storr's School Agricultural Experiment Station. First and Second Annual Report. 1888. Bulletin No. 6. From the Director.

Superintendent of Public Schools. Philadelphia. Annual Report for 1888. From the Board of Public Education.

Tebbutt's Observatory. Report for 1886. From Prof. John Tebbutt.

Technologist. Vol. 1. From American Iron and Steel Association.

Texas Geological Survey. First Annual Report. 1889. Bulletin No. 4. From the Director.

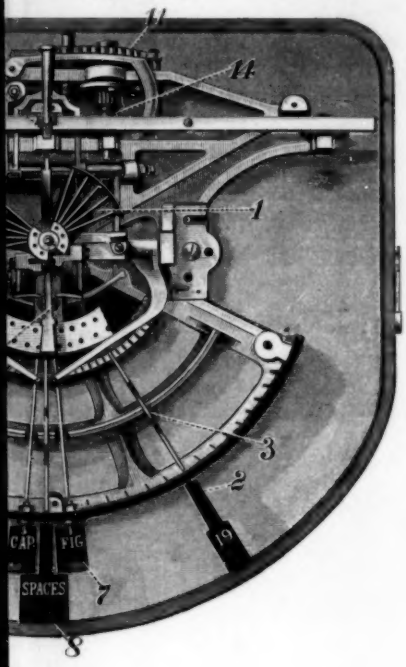
Treat, C. R. Sanitary Entombment. From the Author.

Tucker, Willis G. Report to New York State Board of Health. From the Author.

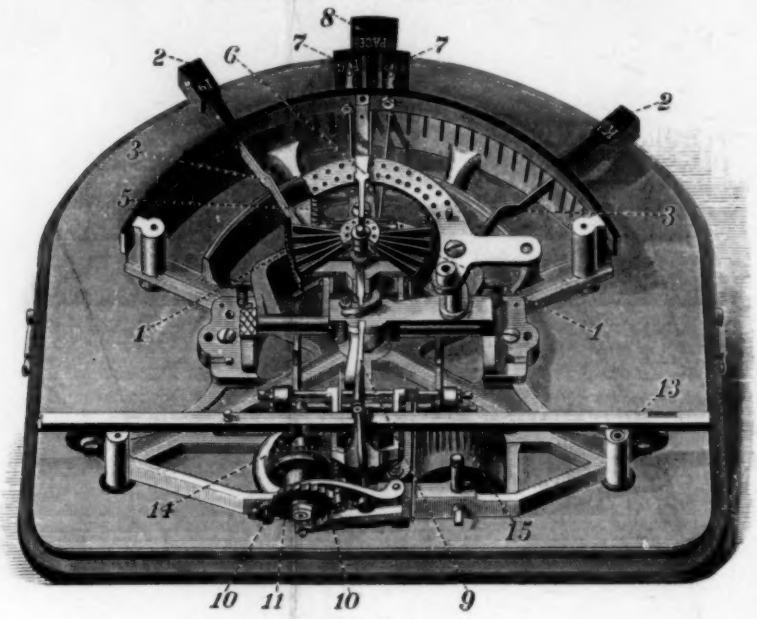
Tyndall, J. Heat Considered as a Mode of Motion. From Spencer Fullerton.

THE HAMMOND TYPEWRITER.

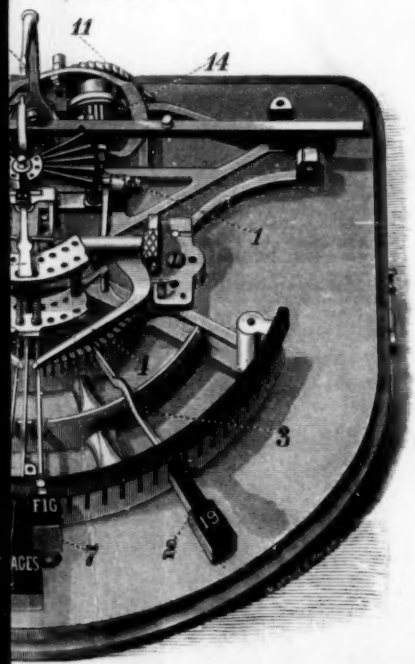
deal. (Top view.)



Skeleton Ideal. (Rear view.)



eal. (Front view.)



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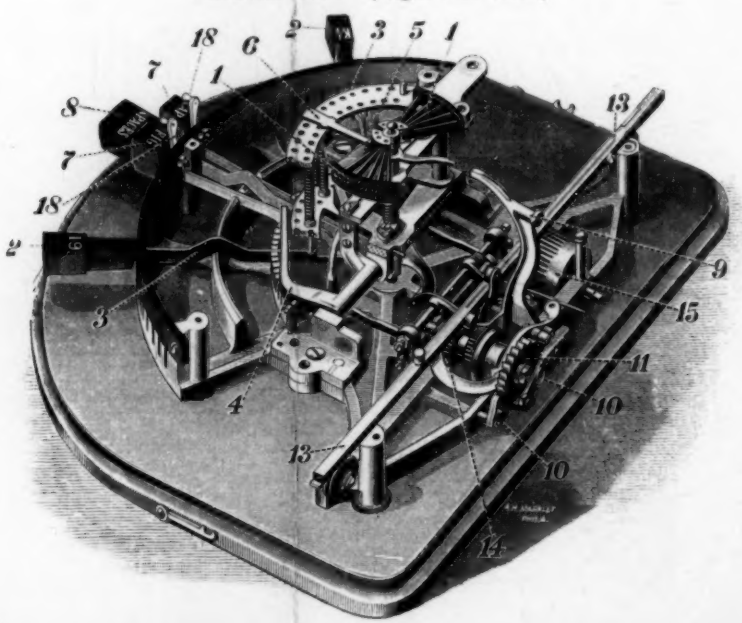
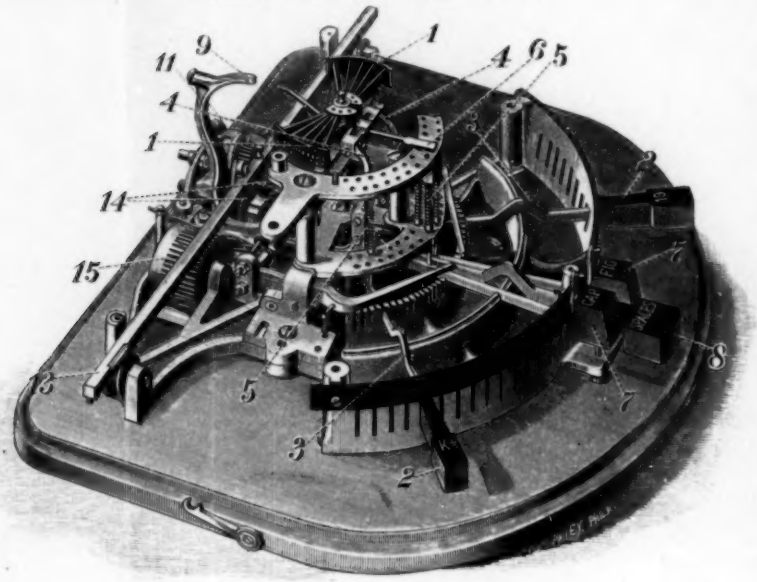
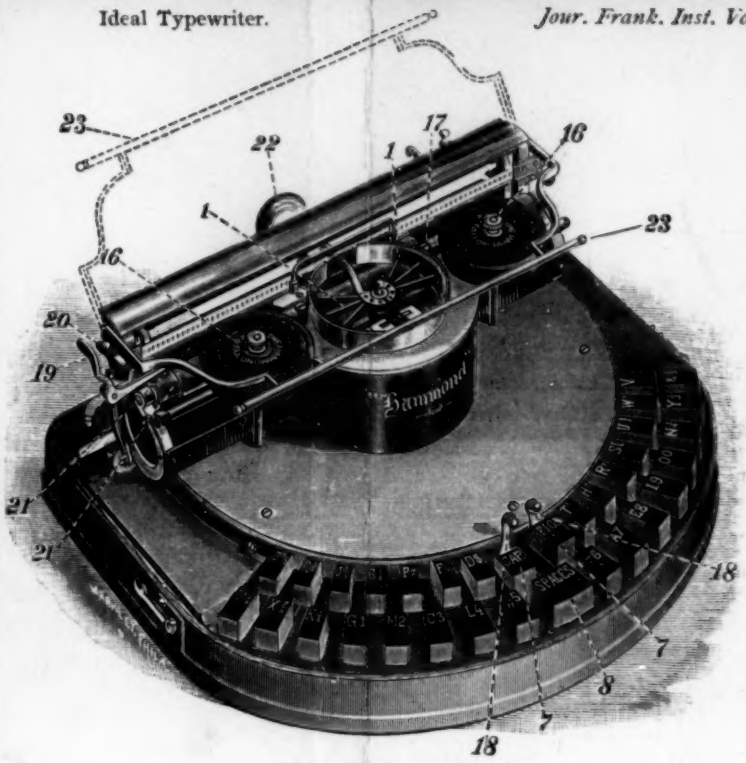


Skeleton Ideal. (Left front view.)



REFERENCES

1 1, Segments containing type-forms.
2, 2, Keys in key-board.
3, 3, Key levers.
4, 4, Levers from key levers 3, 3 to sectors 1, 1.
5, Pins to arrest stop-bar.
6, Stop-bar on arbor of segments 1.
7, 7, Keys to raise and lower segments 1, 1.
8, Space key.
9, Impression lever.
10, Pallets for spacing.
11, Escapement wheel.
12, Paper carriage.
13, Rack controlling paper carriage.
14, Pinion engaging in rack and controlled by escapement wheel 11.
15, Spring barrel for propelling rack.
16, 16, Reels for carrying ink ribbon 17.
17, Ink ribbon.
18, 18, Latches for keys 7, 7.
19, Levers to disengage pallets 10 from escapement wheel 11.
20, Lever to actuate paper rollers 21 to space lines.
21, 21, Paper rollers in carriage 12.
22, Bell to signal end of lines.
23, Paper rack in dotted lines as in use. In full lines as folded to fit case.



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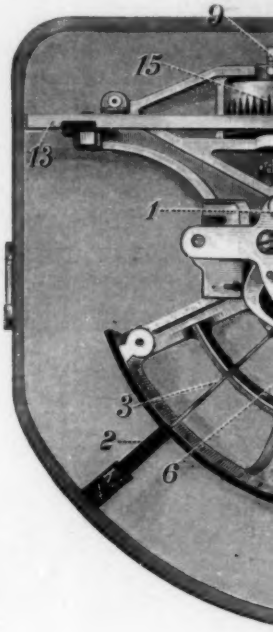

Universal Typewriter.

Skeleto

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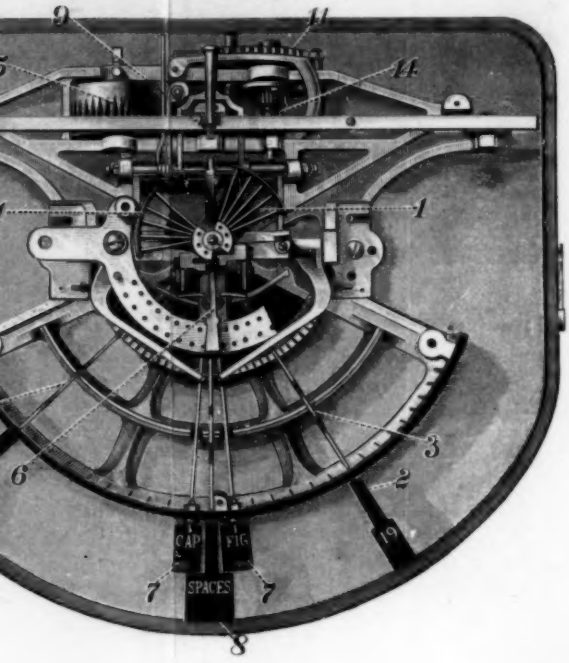

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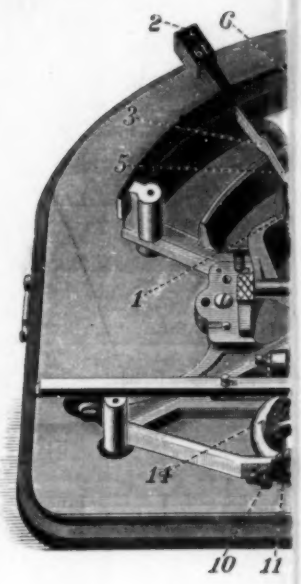

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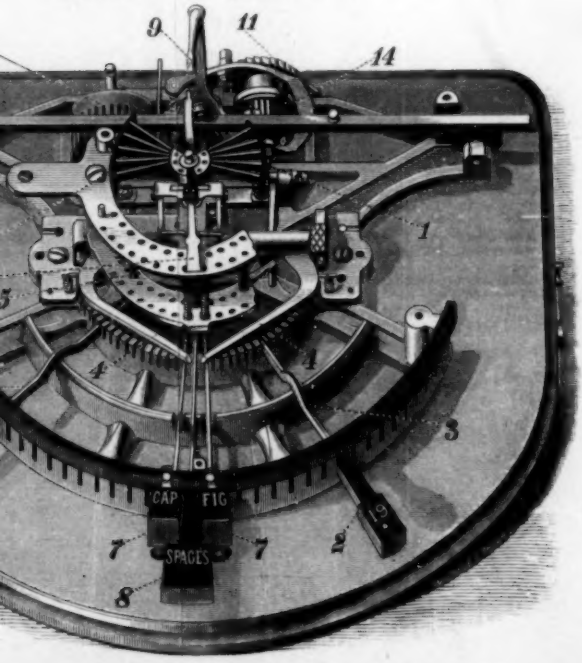
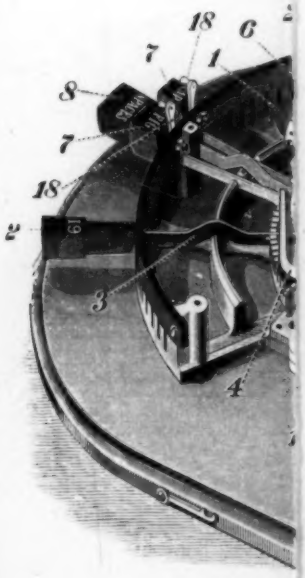
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